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MODEL VM-3

ATTENUATOR AND SIGNAL CALIBRATOR

INSTRUCTION MANUAL

WEINSCHEL ENGINEERING

GAITHERSBURG, MARYLAND

MODEL VM-3

ATTENUATOR AND SIGNAL CALIBRATOR

INSTRUCTION MANUAL

The Model VM-3 Attenuator and Signal Calibrator described in this publication is manufactured under and protected by the following United States Patents: 3,098,968; 3,104,354; RE 25,396

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DESIGNERS AND MANUFACTURERS OF PRECISION MICROWAVE EQUIPMENT

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VM-3
No65

TABLE OF CONTENTS

Paragraph		Page
	SECTION I GENERAL INTRODUCTION	
1.1	Scope of Manual	1-1
1.2	Purpose of Equipment	1-1
1.3	Specifications	1-1
1.4	Description	1-1
1.4.1	Mechanical	1-1
1.4.2	Electrical	1-1
1.5	Accessories	1-11
	SECTION II INITIAL PREPARATION FOR USE	
2.1	Unpacking	2-1
2.2	Installation	2-1
2.3	Preliminary Operation Check	2-1
2.4	Preliminary Setup Precautions	2-2
	SECTION III OPERATING INSTRUCTIONS	
3.1	Uses	3-1
3.2	Mixer and Local Oscillator Selection	3-2
3.3	Operation of the Optical Readout Device	3-3
3.4	Attenuation Measurements Procedures	3-3
3.4.1	External Modulation	3-3
3.4.2	CW	3-10
3.5	Receiver Operation Procedure	3-14
3.5.1	External Modulation	3-14
3.5.2	CW	3-14
3.6	Modulation Measurements Procedure	3-15
3.6.1	Amplitude Modulation Measurements	3-15
3.6.2	Frequency Modulation Measurements	3-17
	SECTION IV THEORY OF OPERATION	
4.1	Introduction	4-1
4.2	Mixers	4-1
4.3	30 Mc Source	4-1
4.4	30 Mc Standard Piston Attenuator	4-2
4.5	Diode Switch and Noise Generator	4-2
4.6	Signal Combiner	4-3
4.7	30 Mc IF Amplifier and Discriminator	4-4
4.8	AGC Amplifier	4-4
4.9	Amplitude Comparator	4-4
4.10	Automatic Frequency Follower Circuits	4-4
4.11	Meter Circuits	4-5
4.12	1-Kc Source	4-6
4.13	Power Supplies	4-7

ADDENDUM NO. 1 TO INSTRUCTION MANUAL FOR

MODEL VM-3 ATTENUATION AND SIGNAL COMPARATOR

Pages 3-11 and 3-12. Change paragraph (f.) to read as follows:

(f.) 1. Disconnect the signal source or insert sufficient attenuation (at least 140 dB) in the signal path to isolate the mixer input from the RF source.

2. Switch the Function Selector switch to the CW Attenuation Measurement position, and set the Standard Attenuator to 140 dB.

3. Push the Depress For Zero button, and adjust the Zero Adjust knob to obtain a null reading on the Amplitude Balance meter.

4. Turn the Zero Signal Balance knob (red) counterclockwise until stopped.

5. Adjust the Tuning Control knob (black) until the indicator of the Amplitude Balance meter swings to the right side of the center position. Then adjust the same Tuning Control knob (black) to obtain a null reading on the Frequency Deviation meter.

6. Adjust the Zero Signal Balance knob (red) clockwise to obtain a null reading on the Amplitude Balance meter and simultaneously adjust the Tuning Control knob (black) as required to maintain a null reading on the Frequency Deviation meter.

Note 1. If the above balancing and tuning procedure is not properly performed, the FM output will appear as shown in figure 3.14. If mixers other than Weinschel units are used, the cable connecting the mixer output to the VM-3 input should be as short as possible to insure proper operation of the circuit.

Note 2. If null readings on the Amplitude Balance meter and the Frequency Deviation meter are erratic, leakage from other sources being operated at the same frequency should be investigated.

Page 4-3. Change lines 2 and 3 of paragraph 1 to read as follows:

The circuit employs a NE-7 neon lamp (Weinschel part no. PL-4) in series with a 1 megohm potentiometer.

Page 6.2. Change electrical parts list to read as follows:

C113	P	Capacitor, tubular ceramic, 15 pf	37-8-15

Page 6-17. Change electrical parts list to read as follows:

R105	GG	Resistor, variable, 1 MΩ, 2W	20-89

Paragraph		Page
	SECTION V SERVICING INSTRUCTIONS	
5.1	Maintenance	5-1
5.1.1	General	5-1
5.1.2	Replacement of Tubes	5-1
5.1.3	Replacement of Transistors	5-2
5.1.4	Replacement of Components	5-2
5.1.5	115/220 Volt Operation	5-3
5.1.6	Cooling Fan and Filter Maintenance	5-3
5.1.7	Optical Readout Bulb Replacement	5-3
5.1.8	Optical Readout Alignment and Maintenance	5-4
5.2	Compliance Tests	5-6
5.2.1	Introduction	5-6
5.2.2	Equipment Required	5-6
5.2.3	Power Supplies	5-7
5.2.4	30 Mc Attenuator Accuracy and Linearity	5-10
5.2.5	Reference Oscillator	5-11
5.2.6	IF Amplifier	5-14
5.2.7	IF Input Tuning and Amplifier Alignment	5-15
5.2.8	AM Modulation	5-17
5.2.9	FM Modulation	5-18
5.2.10	Receiver Operation	5-19
5.2.11	Insertion Loss	5-19
5.2.12	Output Jacks	5-20
	SECTION VI PARTS LIST	
6.1	Introduction	6-1
6.2	Parts Lists	6-1
	SECTION VII - APPENDIX	
	Modifications For AFF Operation	7-1

LIST OF ILLUSTRATIONS

Figure		Page
1.1	Front Panel View of Attenuator and Signal Calibrator, Model VM-3	-v-
1.2	Simplified Block Diagram of Model VM-3	1-5
2.1	Model VM-3 Shown in Use with the Model HO-1 Heterodyne Mixer-Oscillator	2-4
3.1	Typical 1507 Series Coaxial Mixer	3-2
3.2	Setup for Insertion Loss Measurement Coax	3-3
3.3	Setup for Insertion Loss Measurement in X-Band Waveguide	3-4
3.4	1 KC Square Wave	3-5
3.5	Modulation not in Counterphase (External Modulation)	3-6
3.6	Modulation not in Counterphase (External Synchronization)	3-6
3.7	Modulation Phase, But Improper Duty Cycle (External Synchronization)	3-6
3.8	Duty Cycle Correct, But Fine Phase Out of Adjustment (External Synchronization)	3-7
3.9	Duty Cycle and Phase Correctly Adjusted (Ext. Sync.)	3-7
3.10	FM Output with Frequency Deviation and FM present	3-8
3.11	Slow AFF Only	3-8
3.12	Slow and Fast AFF	3-9
3.13	AM Output AT - 100 DBM	3-9
3.14	FM Output With Mismatch	3-11
3.15	FM Output With Fast Signal Out of Phase	3-13
3.16	Typical Setup for Calibration of a Signal Generator (External Synchronization Operation)	3-15
3.17	Typical Setup for Calibration of a Signal Generator (External Modulation Operation)	3-16
3.18	AM Output with Non-Symmetrical Amplitude Modulated Signal	3-17
3.19	Typical Setup for the Calibration of a Signal Generator (CW Operation)	3-17
5.1	Side View Model VM-3, Cabinet Removed	5-8
5.2	3/4 View Model VM-3, Upper Chassis Raised	5-9
5.3	Setup for Calibration of 30 MC Attenuator	5-10
5.4	Block Diagram for 30 MC Source Stability Test	5-13
5.5	RF Peak Detector	5-13
5.6	0-3 V DC Source	5-13
5.7	30 MC Output at J-16	5-13
5.8	Setup for IF Amplifier Center Frequency Test	5-14
5.9	RF Sweep Generator Setup	5-16
5.10	IF Amplifier Response (1.5 VPP)	5-16
5.11	30 MC Discriminator Response	5-17
6.1	Rear View Model VM-3, Cabinet Removed	6-31
6.2	Top View Model VM-3, Cabinet Removed	6-32
6.3	Bottom View Model VM-3, Cabinet Removed	6-33
6.4	Closeup View of Readout Device, Face Plates Removed	6-34
6.5	Front View of 30 MC Attenuator and Readout Assembly Removed from VM-3	6-34

LIST OF ILLUSTRATIONS (CONT'D.)

Figure		Page
7.1	General AFF Klystron Schematic	7-1
7.2	Klystron Power Supply Modification	7-2
7.3	Simplified AFF Circuit Schematic	7-3
7.4	Circuit Schematic Showing Klystron Repeller Lead Separation	7-3

LIST OF TABLES

Table		Page
1.1	Specifications	1-2
1.2	Front Panel Controls and Indicators	1-6
1.3	Mixers	1-11
5.1	Tube Complement	5-1
5.2	Transistor Complement	5-2
5.3	Test Equipment Required	5-3
6.1	Electrical Parts List	6-2
6.2	Manufacturer's Code	6-30

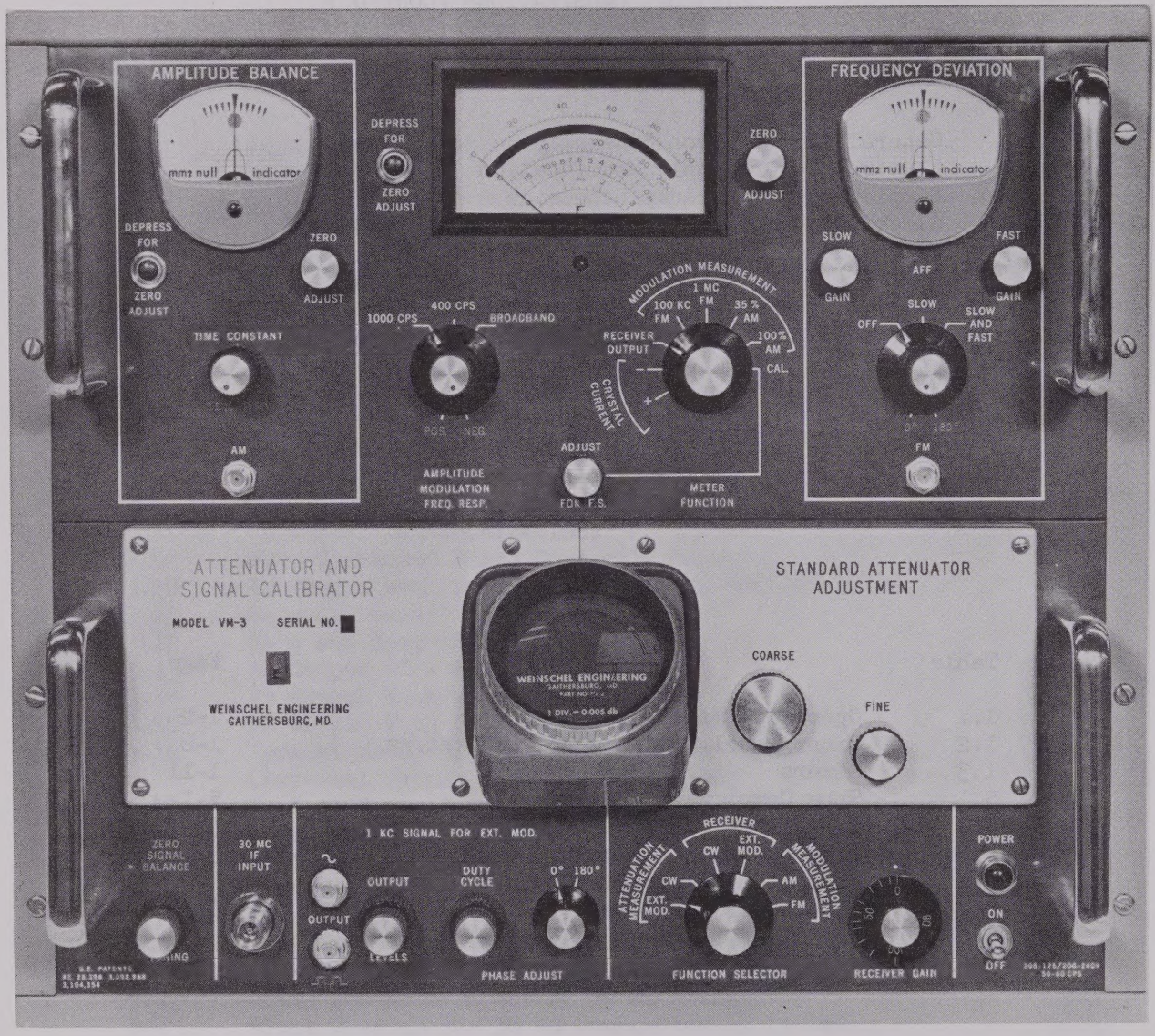


Figure 1.1

Front Panel View of Attenuator and Signal Calibrator

Model VM-3

SECTION I

GENERAL INTRODUCTION

1.1 SCOPE OF MANUAL

This manual covers the description, operating instructions, theory of operation, maintenance instructions, and parts breakdown for the Model VM-3 Attenuator and Signal Calibrator S/N 19 and above manufactured by Weinschel Engineering Co., Inc., Gaithersburg, Maryland. The instrument is shown in fig. 1.1.

1.2 PURPOSE OF EQUIPMENT

This equipment is intended to be used for those applications where the precise measurements of rf power ratios is required over large dynamic ranges. In addition to these applications, the Model VM-3 will also directly measure both AM and FM of the input signal.

Some typical examples of uses for the Model VM-3 are: measurement of insertion loss of microwave devices of as much as 100 db rf in a single step, calibration of the internal output attenuator of a signal generator, check the signal purity and the percentage of modulation of RF signals, operate as a sensitive receiver of CW or modulated signals to measure antenna patterns over a 35-db range, measure VSWR at low levels, and measure leakage in excess of 140 db.

1.3 SPECIFICATIONS

The specifications of the instrument are listed in Table 1.1.

1.4 DESCRIPTION

1.4.1 Mechanical. The Model VM-3 is complete in one unit including its own cabinet. With the cabinet removed the unit may be mounted into a standard 19" relay rack. The cabinet, has a blower mounted in the rear which is interlocked with the VM-3 so that the VM-3 is inoperative unless the blower is plugged into the VM-3. A dummy connector is shipped with each VM-3 chassis. This connector is used to bypass the interlock when the VM-3 is out of the cabinet for maintenance or when rack mounted. (See maintenance instructions).

The upper chassis of the VM-3 (See fig. 5.2) is pivoted so that it may be lifted up out of the way for ease of maintenance or removal of the standard attenuator for calibration.

1.4.2 Electrical. The Model VM-3 Attenuator and Signal Calibrator is what is commonly known as a parallel IF substitution system with the added capability for measuring both the FM and AM of signal generators. A simplified block diagram of the VM-3 is shown in Fig. 1.2. The internal RF portion of the VM-3 is comprised of a very stable 30 Mc crystal controlled oscillator and precision 30 Mc waveguide below cutoff attenuator, a signal combining circuit, 30 Mc IF amplifier and 30 Mc discriminator. In addition to these RF circuits, there is a series of circuits to provide detection, modulation, and indication that operate at an audio frequency of 1000 cps.

Table 1.1 Specifications

Specification	Descriptive Data
Frequency Range	10 Mc to more than 40 Gc (determined by accessory equipment used).
Signal, For Loss Measurements and Receiver Operation	CW or 100% square wave modulated by 1000 cps signal from VM-3 (full range operation with either signal).
Input Frequency	30 Mc
Insertion Loss (Attenuation)	Specifications are for operation at microwave frequencies using a typical mixer with an 8-db conversion loss, and using about 1 mw (dependent upon mixer type, see Table 1.3) of local oscillator power. In the case of insertion loss measurements, it is assumed that the test piece is matched and that connector loss is repeatable. Measurements at RF Single Step — 100 db Maximum RF Accuracy vs. Range Step — Accuracy, db 20 db RF — ±0.02 40 db RF — ±0.04 60 db RF — ±0.07 80 db RF — ±0.27 100 db RF — ±0.50
Incremental Accuracy/10 DB Step	RF Signal Level at Mixer Input — Accuracy, db -15 to -25 dbm — 0.10 — Effect of mixer non-linearity -25 to -35 dbm — 0.02 — Effect of mixer non-linearity -35 to -85 dbm — 0.01 Av. (0.05 max. for 50 db range); 0.015 10 max. -85 to -95 dbm — 0.1 — Effect of Noise -95 to -105 dbm — 0.2 — Effect of Noise -105 to -115 dbm — 0.3 — Effect of Noise

Table 1.1 (Cont'd)

Specification	Descriptive Data
Null Meter Sensitivity (Center Balance)	0.1 dB minimum (zero to minus or zero to plus) full scale from -15 to -90 dBm. 1.0 dB minimum (zero to minus or zero to plus) full scale from -90 to -115 dBm. Note: Total scale length; about one inch for 10 divisions (±5 about center).
Amplitude Modulation	Meter Ranges: 35% and 100% full scale on 4-1/2 inch meter. Accuracy Around Band Center Frequency: ±5% of full scale. Frequency Response (3 dB points): Broadband; 50 to 50,000 Hz. 400 Hz; 370 to 430 Hz. 1000 Hz; 950 to 1050 Hz.
Frequency Modulation	Meter Ranges: 100 Kc and 1 Mc peak-to-peak Accuracy: ±15% of full scale Frequency Response: 50 to 10,000 cps Maximum Allowable AM: 90%
Receiver Operation	Sensitivity: -130 dBm at 30 Mc Range: 35 dB square law using external VSWR meter within RF level of -30 to -115 dBm; lowest preferred RF level for full 35 dB range: -60 dBm to -95 dBm, 15 dB square law using front panel meter.
AFF - "Fast", "Slow"	Lock on Range: ±5 Mc Control on "Slow": IF offset reduction typically 100/1 (RF signal drift of 1 Mc causes only 10 kC IF drift). Control on "Fast": 20/1 reduction of peak-to-peak incidental FM for most signals at a modulation frequency from 50 cps to 10 Kc at maximum setting; Example, 1 Mc incidental FM is reduced to 50 Kc. Insulation: 3000V from chassis
30 Mc Attenuator	Readout: Optical Micrometer Mechanical Accuracy: ±0.0001" Attenuator Accuracy: >0.01 dB/10 dB at 30 Mc over linear region (below -25 dBm) Typical Nonlinearity: <.05 dB/10 dB between -20 dBm and -25 dBm; <.15 dB/10 dB between -12 dBm and -20 dBm. (in the nonlinear region the measured power ratio is larger than the actual one; thus this attenuator nonlinearity partially cancels the mixer nonlinearity)
IF Amplifier	Center Frequency: 30 Mc Bandwidth: 1 Mc Maximum Voltage Gain: $>10^6$

Table 1.1 (Cont'd)

Specification	Descriptive Data
Reference Oscillator	Frequency: 30 Mc ± 0.002% (crystal controlled) Amplitude Stability: ±0.005 db/10 minutes ±0.005 db for ± 10% line voltage changes Modulation Switching: 1000 cps internal or external synchronized by internal oscillator.
Metering	#1 Amplitude Balance: Center balance meter - 1" scale length #2 Frequency Deviation: Center balance meter - 1" Scale length #3 Mirror Backed, 4-1/2" Scale: a. Crystal Current: 3 ma full scale b. AM: 0-35% full scale, 0-100% full scale c. FM: 0-100 Kc peak-to-peak full scale, 0-1 Mc peak-to-peak, full scale d. Receiver: 0-15 db square law
Output Jacks	AM: Low impedance output from cathode follower. FM: High impedance output directly from discriminator Video Out: High impedance output from square law detector. Square Wave: 0-65V peak-to-peak for external modulation. Sine Wave: 0-30V peak-to-peak with 45° phase shift adjustment with respect to square wave. **30 MC: 1 Volt RMS into 50 ohms**
Accessories	See Paragraph 1.5
Weight	95 Pounds, including cabinet
Dimensions	Out of Cabinet: 19" wide rack panel; 15-3/4" high; 18-1/2" depth behind panel; 3" panel to front of guard handles. In Cabinet: 21" wide, including side carrying handles; 17-1/2" high; 19" deep cabinet plus 3" to front of panel guards.
Ventilation	Fan and air filter in cabinet

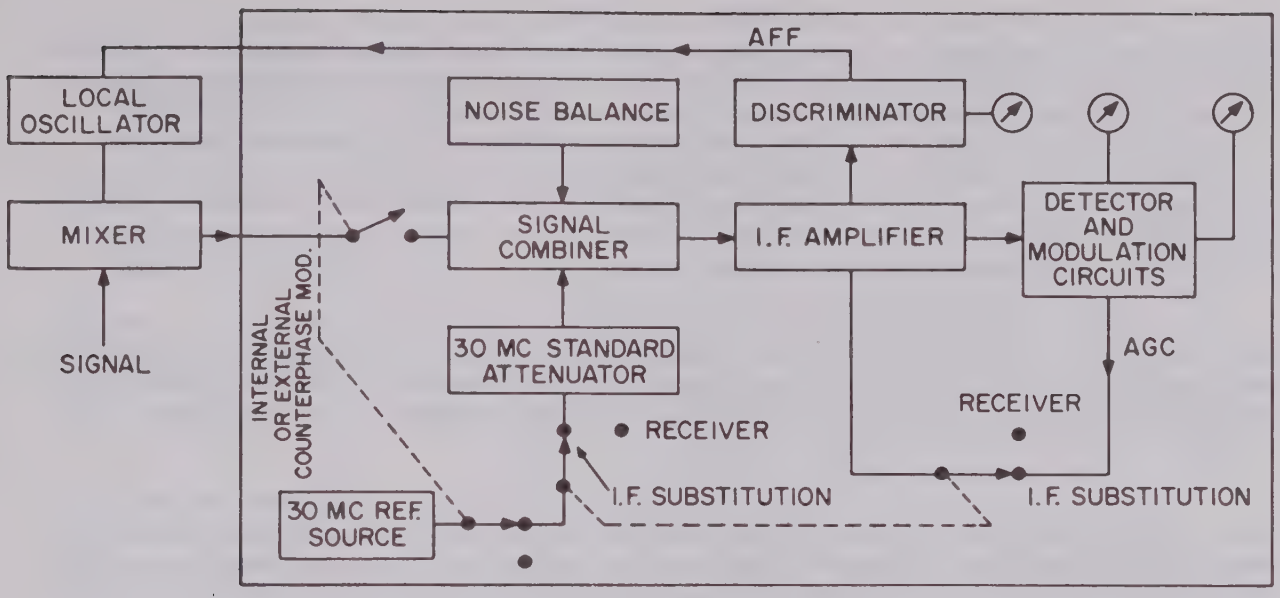


Figure 1.2 Simplified Block Diagram of Model VM-3

In actual operation an external signal generator and local oscillator are connected to a 30 Mc linear mixer and the microwave signal transferred to an IF of 30 Mc. This external 30 Mc IF signal is compared with the internal 30 Mc reference signal which may be adjusted in level by using the calibrated precision waveguide below cutoff attenuator. These two 30 Mc signals are alternately received in the IF amplifier. The external signal is either 100% square wave modulated in counterphase with the internal 30 Mc signal or if the external signal is a cw signal it is alternately chopped on and off by a 1000 cps electronic switch inside the VM-3. These two alternate signals are fed to the IF amplifier which is used only to detect a difference in level between the two 30 Mc signals. For this reason it can be seen that the gain of the IF amplifier is not critical. An AGC loop is provided to the IF amplifier which automatically keeps the detector sensitivity constant. In operation, the two signals are adjusted to the same amplitude which is indicated by a null on the "Amplitude Balance" indicator, after which the unknown microwave device is inserted into the measurement channel and the system is again brought to null be adjusting the waveguide below cutoff substitution attenuator. The difference in the two settings of the standard attenuator is a measure of the attenuation or insertion loss of the unknown device.

A special noise balance circuit is provided which introduces extra noise into the reference signal to balance the noise generated by the mixer crystal in the signal channel. This is only necessary when the internal switch modulator is used. The noise balance circuit enables measurements to be made far below -90 dbm using cw rf sources without introducing a sizeable error into the measurement due to noise.

To insure that the signal source and local oscillator remain at an IF or difference frequency of 30 Mc, the output from the 30 Mc discriminator is fed into an automatic frequency follower circuit which generates a positive or negative correction signal which may be applied to the local oscillator to enable the local oscillator to follow or track the signal source at a difference frequency of 30 Mc. This circuit has the novel function of being able to operate in a combined "Slow and Fast" mode which reduces the unwanted frequency modulation present at the output of the mixer and increases the accuracy of measurement by providing a pure and stable 30 Mc mixer output.

The VM-3 has built-in modulation measuring circuits which may be used in the calibration of the AM and FM of the signal generator. In measuring the percent modulation AM of a signal generator, the purity or symmetry of the modulation signal may also be checked. These circuits also allow measurement of the incidental FM present on the microwave signals.

The waveguide below cutoff attenuator is of course the heart of the measuring system. The rf portion of this attenuator consists of an accurately honed, stainless steel tube with launching and receiving coils and mode suppressor. The tube supports a below cutoff TE_{11} mode which attenuates along the axis at a rate that can be accurately calculated. Therefore, the major requirement is to be able to make a very precise mechanical measurement. The separation between the launching and pickup coils of the VM-3 is the measure of attenuation, and is read on a non-wearing optical micrometer to an accuracy of 0.0001". The scale on the optical readout is calibrated directly in db. The entire attenuator and optical readout assembly can be easily removed for calibration by NBS for those laboratories which require traceability to National standards. (See Section IV for Theory of Operation).

All operating controls and indicators are on the front panel and identified by function. Table 1.2 lists the description and function of the items.

TABLE 1.2 FRONT PANEL CONTROLS AND INDICATORS

Item	Description and Function
AMPLITUDE BALANCE Indicator	A standard "0" center meter which is used to indicate the degree of unbalance between the internal and external 30 Mc signals.
DEPRESS FOR ZERO ADJUST Buttons (two are provided) AMPLITUDE BALANCE Meter MODULATION Meter	A push-button that shorts the signal to ground when it is depressed. This permits electrical zero adjustment of the meters.
ZERO ADJUST Controls (two are provided) AMPLITUDE BALANCE Meter MODULATION Meter	These potentiometers are used for adjusting the electrical zero under no-signal conditions.

TABLE 1.2 CONTD.

Item	Description and Function
TIME CONSTANT SENSITIVITY (with switch)	Dual concentric, continuously variable potentiometers. The larger black knob increases the time constant of the "Amplitude Balance" indicator when turned clockwise. The smaller red knob increases the full scale sensitivity of the "Amplitude Balance" indicator when turned clockwise. In the full counterclockwise position this control activates a switch which sets the circuit to a fixed sensitivity level depending upon the selected value of R-518.
AM Connector (BNC)	Video output from the IF amplifier, DC coupled through a cathode follower. Allows presentation of the amplitude unbalance to be displayed on an oscilloscope.
AMPLITUDE MODULATION FREQ. RESP. 1. 1000 cps 2. 400 cps 3. Broadband 1. Pos. 2. Neg.	Concentric switches whose functions are as follows: The larger black knob selects the proper frequency response for the internal Amplitude Modulation measuring circuits. The smaller red knob reverses the polarity of the diode peak detector which provides a rapid means of determining if the AM signal is unsymmetrical. The indication on the "Modulation Meter" should remain constant if signal is symmetrical.
MODULATION METER	A multi-range indicator which reads: Crystal Current - 0-3 ma F.S. Receiver Output - 0-15 db (square law) FM - 100 KC F.S. FM - 1 MC F.S. AM - 100% F.S. AM - 35% F.S. Ranges may be selected by the "METER FUNCTION" selector switch.
METER FUNCTION Selector Switch	An 8 position selector switch which provides the proper full scale meter indication for the various operating modes of the VM-3
ADJUST FOR F.S. Control (Function Selector must be in AM Modulation Measurement Position)	When the "METER FUNCTION" switch is in the "CAL." position, this potentiometer sets the AGC level so that the "Modulation Meter" full scale deflection corresponds to a predetermined CW RF level.

TABLE 1.2 CONTD.

Item	Description and Function
FREQUENCY DEVIATION	A standard zero center meter which is used to indicate the frequency deviation between the 30 Mc IF signal and the internal 30 Mc standard source signal.
AFF FUNCTION Switch	Concentric switches which control the function of the AFF circuits. The larger black knob controls the following:
1. OFF	Turns the AFF off.
2. SLOW	Turns the AFF circuit on so that it responds to slow frequency changes and generates corresponding correction signals.
3. SLOW AND FAST	Same as SLOW position with an additional fast feedback signal which bypasses the slow feedback synchronous detector and is directly applied to the correction circuit. This signal minimizes the high frequency FM
1. 0^{o} 2. 180^{o}	The smaller red knob when switched from one of these two positions to the other, reverse the polarity of the correction voltage which is applied to the external L.O. circuit.
SLOW GAIN Control	A potentiometer that controls the gain of the slow AFF circuit. (Too much gain will cause oscillation and varies with different L.O.'s.
FAST GAIN Control	A potentiometer that controls the gain of the fast AFF circuit. (Too much gain will cause oscillation and varies with different L.O.'s.
FM Connector (BNC)	The output from the 30 MC discriminator is DC coupled to the front panel and provides for the Frequency Deviation signal to be displayed on as oscilloscope.
STANDARD ATTENUATOR	The optical device located in the center of the VM-3 front panel provides the read out for all settings of the Standard Attenuator to an accuracy of 0.0001" and a resolution of 0.005 db per division.
COARSE FINE	A coarse rack and pinion drive for the Standard Attenuator. A vernier drive for the Standard Attenuator.

TABLE 1.2 CONTD.

Item	Description and Function
ZERO SIGNAL BALANCE	A potentiometer that varies the amplitude of the internally generated noise. This control is used to balance the external mixer noise when the unit is operated in the CW receiver mode.
TUNING	A variable capacitor which tunes the I.F. input to 30 Mc.
30 MC IF INPUT Connector	Type "N" input connector where the external 30 Mc IF signal is applied to the VM-3
OUTPUT CONNECTORS (BNC)	A 1 KC sine wave output is available for externally synchronizing a signal source modulator. It is variable between 0-30V peak-to-peak. Phase may be shifted ± 45° with respect to Square Wave.
(BNC)	A 1 KC square wave output is available for externally modulating a signal source. It is variable between 0-65V peak-to-peak.
OUTPUT LEVEL Controls	Dual concentric potentiometer controls for varying the amplitude of the 1 KC sine wave and square wave outputs. The larger black knob controls the amplitude of the 1 KC sine wave between 0-30V peak-to-peak. The smaller red knob controls the amplitude of the 1 KC square wave between 0-65V peak-to-peak.
DUTY CYCLE	Dual concentric potentiometer controls which vary the duty cycle and fine phase of the 1 KC signals. The larger black knob adjusts the "duty cycle" of the square wave output located on the front panel and also the internal square wave signals that switch both the 30 MC standard source and the internal 30 MC IF switch.
FINE Phase Adjust	The smaller red knob provides a "Fine" phase Adjustment of ± 45° between the sine wave output and the square wave and internal 1 KC reference signals.
0° - 180 ° Phase Adjust	A switch which provides a fixed phase shift of 180° between the internal 30 MC IF switch and the 30 MC standard source switch relative to the square wave output, sine wave output and 1 KC reference signals. It also reverses the phase of the AFF fast feedback signal.

TABLE 1.2 CONTD.

Item	Description and Function
FUNCTION SELECTOR	A 6 position selector switch that selects the proper internal operation of the VM-3 in conjunction with the "Meter Function" switch for the particular type of measurement being made.
RECEIVER GAIN	A potentiometer that varies the cathode bias on 3 stages of the IF amplifier to control the gain when the "Function Selector" switch is in the Receiver position.
Primary Power Indicator Lamp	A red indicator lamp which comes on when the primary power switch is placed "ON".
ON-OFF (Primary Power Switch)	A two-position toggle switch for applying primary power to internal circuits.

1.5 ACCESSORIES

Model 1507/1508 Mixer Series.

The Model 1507/1508 Series of coaxial and waveguide mixers is recommended for use as accessories with both the Model VM-1 and VM-3 IF Subsitiution Systems.

The 1507 Series covers the frequency range from 10 mc to 11 Gc in five models. Hybrids are used on all models to isolate the local oscillator and signal channels. Above 1 Gc two tunnel diode mixers are used in parallel; below 1 Gc two parallel crystal mixers are used. Because of the action of the Hybrid the input VSWR is relatively low, and for many applications it is not necessary to tune the input signal channel.

The 1508 Series covers the frequency range from 1 Gc to 18 Gc in four models. Two of the mixers cover the coaxial frequency range from 1 to 10 Gc and the other two cover X-band and P-band in waveguide. The Model 1508 series requires at least 20 milliwatts of local oscillator power since the coupling between the local oscillator and mixer is made through 10 db couplers. Also, since only one mixer is used, the input VSWR is generally higher than on the 1507 Series.

TABLE 1.3 MIXERS

Frequency Range	Model	Remarks
10 mc - 1 Gc Coax	1507A	Low L.O. power. Reasonably good input VSWR. Tuner may not be required
1 - 2 Gc Coax	1507B	
2 - 4 Gc Coax	1507C	
4 - 8 Gc Coax	1507D	
7 - 11 Gc Coax	1507E	
1 - 4 Gc Coax	1508A	High L.O. power. Input tuner usually required.
4 - 10 Gc Coax	1508B	
8.2 - 12.4 Gc Waveguide	1508X	
12.4 - 18.0 Gc Waveguide	1508P	

Model HO-1 Heterodyne Mixer-Oscillator

The Weinschel Engineering Model HO-1 Heterodyne Mixer-Oscillator provides a complete local oscillator-mixer system for the heterodyne conversion to 30 mc of signals in the frequency range from 10 mc to 12.4 gc. The Model HO-1 oscillator module, together with the Model HO-A Mixer package and the Model DS-109 Double Stub Tuner - supplied as accessories - were designed to be used with the Weinschel Model VM-3 Attenuator and Signal Calibrator and similar heterodyne receivers operating at 30 mc. Use of the HO-1 eliminates the need for 6 or 7 local oscillators with associated power supplies and mixers.

The Model HO-1 contains two microwave oscillators together with their associated power supplies. Both oscillators are required for dual conversion in the signal frequency band from 10 mc to 1990 mc. The first oscillator is tunable from 2020 mc to 4200 mc, while the second operates at a fixed frequency of 2060 mc. From 1990 to 4150 mc fundamental mixing is employed, and from 4150 to 12,400 mc second and third harmonic mixing is used. The direct-reading dial is calibrated for SIGNAL FREQUENCY operation in the fundamental, harmonic, and dual conversion modes. Only one knob is needed for tuning the signal frequency; all voltages are automatically tracked.

The HO-A Mixer is supplied as part of the HO-1 system, and is connected to the HO-1 oscillator module by means of cables which are provided. The HO-A contains the necessary directional couplers, filters, and diode mixers to convert an external signal to a 30-mc IF over the full frequency range from 10 mc to 12.4 gc. External signal sources must provide at least -10 dbm output available at the HO-A input to use the full dynamic range of the VM-3.

Dual Conversion Operation: Frequency conversion to 30 mc of a signal between 10 and 1990 mc is obtained by using two mixers. The first mixer uses the difference between the tunable oscillator of the HO-1 and the RF signal to obtain a first IF signal at 2090 mc. A sharply tuned filter between the first and second mixers suppresses any mixer products other than the desired 2090 mc first IF signal. The second mixer uses the 2060 mc fixed oscillator signal to convert the 2090 mc IF signal down to 30 mc.

Fundamental and Harmonic Mixing: In the frequency range from 1990 to 12,400 mc, the RF signal and the tunable oscillator of the HO-1 are connected to the second mixer only, which consists of directional coupler and a tunnel diode. For harmonic mixing, the oscillator signal level is adjusted to generate second and third harmonics in the tunnel diode strong enough to assure linear conversion to 30 mc.

AFF: An AFF (automatic frequency follower) input is provided in the HO-1 to lock the tunable oscillator frequency or its harmonic to a 30 mc difference from the signal frequency. The AFF correction voltage is produced in the VM-3.

The Model HO-1 is ideally suited for use with the VM-3 in general laboratory, standards laboratory, and field applications where ruggedness, high sensitivity, broadband operation and accuracy are important.

SECTION II

INITIAL PREPARATION FOR USE

2.1 UNPACKING

The Model VM-3 is shipped in a double packing case with two inches of packing material between the inner cardboard carton and the outer wooden packing crate. This method of packing complies with MIL-P-116D, Method III and will meet packing requirements for export shipments. The plywood packing case is a 12.0 cube. The marking on the outer shipping crate is in accordance with MIL-STD-129. Exercise normal care when removing the instrument and packing material. The only additional items are the primary power cord with adapter, connector for AFF cable, and this instruction manual.

Examine the instrument for physical damage. Notify the shipping company immediately if evidence of damage is found. If shipped F.O.B. Gaithersburg, Maryland, damage claims must be collected by the consignee. Do not destroy the shipping cartons or packing material until after an agent of the shipping company has examined them. Do not return the instrument to Weinschel Engineering until a claim for damage has been established.

2.2 INSTALLATION

The Model VM-3 is self-contained in its own blower cooled cabinet for use on a laboratory work bench. However, if it is desireable to mount the Model VM-3 in a relay rack, the unit may be removed from its cabinet and bolted in a standard 19" relay rack. In order to remove the VM-3 from its cabinet, the blower fan mounted in the rear of the cabinet must be unplugged from the VM-3. Since this fan is interlocked to the power supply of the VM-3, the adapter plug attached to the rear of the lower chassis will have to be substituted into the receptacle J-2 on the rear apron of the lower chassis. Care must be taken to make sure that the VM-3 is not located in a strong magnetic or electrical field.

2.3 PRELIMINARY OPERATION CHECK

A. Connect the power cord between receptacle on rear of chassis and 50/60 cps AC line (see label on rear of chassis for proper line voltage).

B. Place primary power switch ON. Primary power indicator lamp should light. Allow the instrument to warm up for thirty minutes.

C. If the primary power lamp fails to light, check the blower motor receptacle to be sure it has been plugged in. Also check fuses.

D. Switch the "FUNCTION SELECTOR" Switch to the "ATTENUATION MEASUREMENTS" position. The face of the optical readout device should light when the switch is placed in this position. Alignment of the optical readout should be checked following the procedure outlined in paragraph 5.1.8.

E. Instrument is now ready to use.

NOTE

This instrument was designed for operation from either a 115/220V - 50/60 cps AC line. Prior to shipment from the factory this instrument was wired and tested for proper operation at the voltage indicated on the red "CAUTION" label on the rear of the chassis. (See Paragraph 5.1.5 for instruction on operation at the other voltage).

2.4 PRELIMINARY SET-UP PRECAUTIONS

When microwave attenuation measurements are made in a system that has a resolution of better than 0.003 db, past experience with microwave hardware and ones individual measurement technique become invaluable assets. Such is the case when using the Model VM-3. The high accuracy and resolution of this system bring out the shortcomings of many RF components which have appeared to be most adequate in lesser systems. For this reason we would like to point out some of the pit falls which may be encountered in the RF set-up, external to the VM-3.

First let us consider coaxial set-ups which may differ considerably from the low end of the coax frequency range to say 11 Gc. The availability of such components as slotted lines and tuners at 30 Mc or below require that the user alter his set-ups and operating procedures accordingly. However, there are other problems which, although present at the lower frequencies, become much more severe at the higher frequencies. One serious problem, though not restricted to coax deals with leakage. This is due largely to the type of connectors available for use in coax and also because measurements of 100 db, down to levels below -115 dbm, are relatively new to the measurement field. In set-ups where the unknown device must be taken in and out of the line, extreme care must be taken to be sure that all components are aligned properly. Coaxial set-ups have many discontinuities which change as the set-up is disturbed or put under stress. The connectors are very unrepeatable and can cause many problems especially at the higher frequencies. Coaxial cables also present problems when they are flexed or their positions are disturbed in the set-up. It is advisable to use a completely rigid set-up, if possible, even to the extent of locating the signal source on a "dolly" or other moveable device that will allow a convenient means of inserting a component into the rigid system with good repeatability and minimum mechanical stress. All components should be rigidly supported with waveguide stands or similar devices.

Waveguide set-ups on the other hand are much cleaner to work with than coax since the mismatch losses are fewer and smaller. This does not mean that problems do not exist, but they are easier to cope with than in coax. As an example, the waveguide flanges must be straight and the mating surfaces must be clean and free from "nicks" and "burrs" which might prevent a tight, flush, connection and cause a leakage problem. All flanges must be securely fastened and properly aligned. In sone extreme cases lapping of the flanges on a surface plate may be required. The selection of components is extremely important as many standard "shelf" items that are satisfactory for general lab use become radiation sources in a system of this type. Slide screw tuners which have open slots should

be avoided and only those tuners with covered slots used. Leakage in these covered tuners is negligible. E-H tuners are also good. Some of the "Flap" type of variable attenuators are troublesome and should also be checked. If slotted lines are used to tune the transmission line, they should always be removed prior to making measurements. All cables and connectors or connections should be examined very carefully. A fairly good leakage test is to balance the system at a level somewhat lower than you expect to measure, and move your hand along the system and around the components. If leakage is present, your hand will cause the system null to change. Wrapping connections, joints, and entire components in aluminum foil or some absorbent material can greatly reduce the leakage in particular around the area of the mixer. Silver paint is also a help.

Always be sure to de-tune any reaction type frequency meters which are in the set-up. Be sure that the entire set-up is as rigid and well supported as possible, and that there is no sag, stress, or unnecessary flexing of the system. This includes the use of a very sturdy bench that will not bend or sag in the middle. In all cases the use of high quality components and connectors can not be overemphasized and will contribute considerably to the overall range and stability of the system. All of these things coupled with system noise and the use of good low noise figure mixer crystals determine whether or not the entire dynamic range of the VM-3 may be realized.

Some additional precautions center around the use of internal cavity klystrons for use at the higher frequencies. In this area vibration even from blower motors can cause considerable klystron noise or temperature variations. Water cooling is recommended in conjunction with stable, low ripple, regulated klystron power supplies with DC filaments for the klystron such as the Weinschel series of Power Supply - Modulators and R.F. Sources. Repeller modulation is also recommended with higher frequency klystrons (above 10 Gc), however, care should also be taken in setting up the frequency and adjusting the modulation signal. The klystrons should be tuned so that they operate at the top of their modes and not down on the side of the mode where the output might be erratic. The effects of hum and ripple which cause spurious signals on the output are minimized when operating at the peak of the mode.

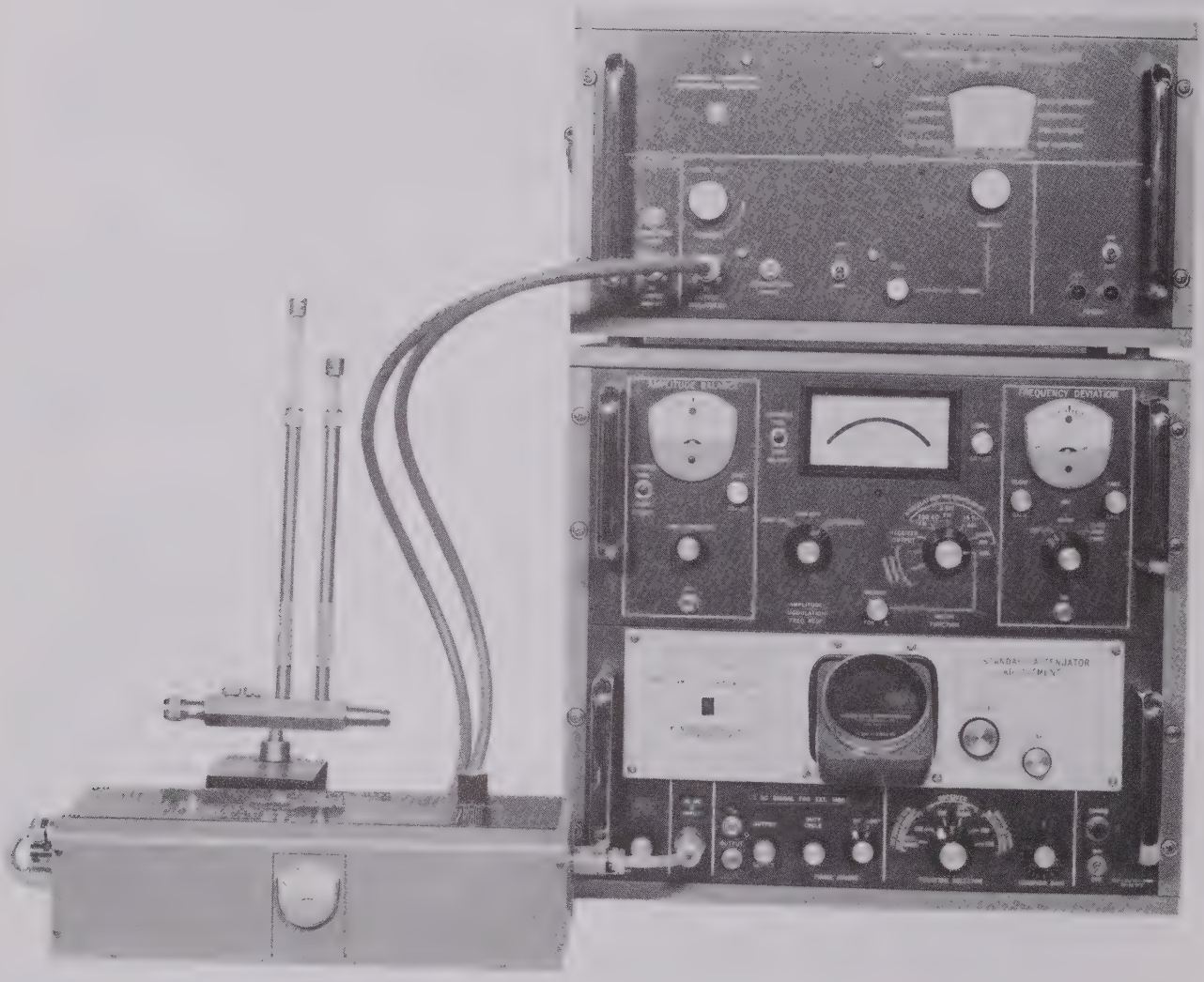


Figure 2.1. Model VM-3 Shown in Use with the Model HO-1 Heterodyne Mixer-Oscillator

SECTION III

OPERATING INSTRUCTIONS

3.1 USES

The Model VM-3 will operate in three different modes. These are as follows:

I. Attenuation Measurements
II. Receiver Operation
III. Modulation Measurements

In each of the first two modes the VM-3 has the ability to function with either an externally modulated or a CW signal applied to the input. In the third mode of operation the VM-3 will measure either percent modulation AM or Incidental FM.

There are many individual measurement applications for the VM-3 which relate to these basic functions and for the most part differ only in the external RF setup. This section of the instruction manual contains a step by step operating procedure for each of the above mentioned modes of operation. A separate procedure is also given for operation with CW sources as well as for internally modulated sources. Block diagrams of typical coaxial and waveguide set-ups are included for reference. It is recommended that when the user determines which of the three areas his particular measurement is in, that he follows that portion of the operating instructions as closely as possible including the associated block diagram.

Although it is not necessary to use an oscilloscope in conjunction with the VM-3, it is strongly recommended that one be used especially during the first few times that the equipment is set up and operated. For this reason, we have included in the operating instructions, a series of wave shapes which will be encountered when setting up and using the VM-3. It is felt that these pictures will greatly assist the operator by simplifying the initial set-up procedure.

It is also felt that the user should read the entire manual prior to operating the equipment and in particular heed the preliminary set-up precautions given in Section II.

NOTE

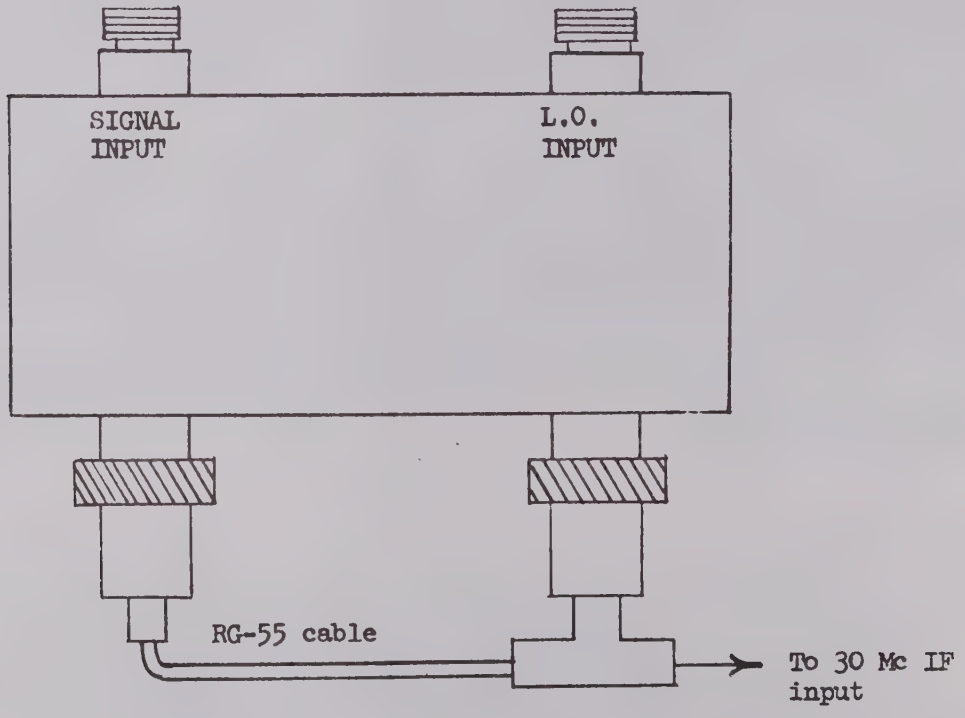
Once the proper local oscillator has been selected for any given set-up, be sure to connect the automatic frequency follower cable between the local oscillator and the VM-3. If the L.O. does not have provisions for A.F.F., be sure to turn the A.F.F. selector switch on the VM-3 to the "OFF" position. (If it is desired to modify the L.O. for A.F.F. operation, see appendix.)

The Local Oscillator should always be operated CW only! Otherwise there will be an error in the measurement.

3.2 MIXER AND LOCAL OSCILLATOR SELECTION

When the Weinschel 1507 series of coaxial mixers is used with the Model VM-3, standard signal generators of the 0-dbm type can be used as local oscillators. These mixers differ from others in that they use two matched diodes, one of which is reversed. The diode current meter will thus indicate 0 under ideal conditions, since the two signals will cancel each other. During the initial setup and tuning procedure the diode currents should be checked individually and should indicate the optimum current recommended for the particular diode. If the optimum diode current is not known, vary the LO power over the range .5 to 1.5 ma. The mixer diode should be operated at the current level that causes the lowest indication on the VM-3 attenuator under amplitude null conditions. This assures operation of the diode with minimum conversion loss. Figure 3.1 shows the proper connections for the 1507 series of coaxial mixers. The remaining portions of the various measurement setups are the same.

When the Weinschel 1508 broadband series is used, a local oscillator with a minimum RF output of 20 mw CW at the desired frequency should be used. The Weinschel series of plugin RF sources meet this RF power requirement, whereas standard signal generators lack sufficient power.



Note: Mixer should be connected directly to 30 Mc IF input. In the event a cable has to be used, it should be kept as short as possible. (Use RG-55 cable only)

Figure 3.1 Typical 1507 Series Coaxial Mixer

3.3 OPERATION OF THE OPTICAL READOUT DEVICE

When the final adjustment is made, or when a null is reached during an attenuation measurement or signal generator calibration, the position of the piston attenuator must be determined to provide a measurement of attenuation in decibels. The following is a step-by-step method of obtaining this reading:

(1) The outer rim around the glass face of the Optical Readout device may be rotated over a full 360 degrees. Rotating the outer rim will also rotate the double line Archimedes spiral on the face of the glass. The rim should be rotated until the double lines of the Archimedes spiral bracket the line division located directly beneath the db figure that appears in the upper right illuminated window on the face of the readout device.

(2) Add the db figure that appears in the upper right window to that which appears in the bottom window. For example, if the db figure in the upper window reads 21 db and the figure in the lower window reads .435, the relative level is 21.435 db.

The figures that appear in the bottom window increase from right to left.

3.4 ATTENUATION MEASUREMENTS PROCEDURE

3.4.1 EXTERNAL MODULATION:

3.4.1.1 RF Setup

Set up the equipment as shown in figure 3.2 or 3.3. The signal source must be 100% square-wave modulated using either the 1-kc square wave or SINE WAVE output from the VM-3. The square wave provides direct modulation while the sine wave is used to synchronize the modulation frequency of the signal source. The choice depends on the type of signal source used. The local oscillator is set for CW operation.

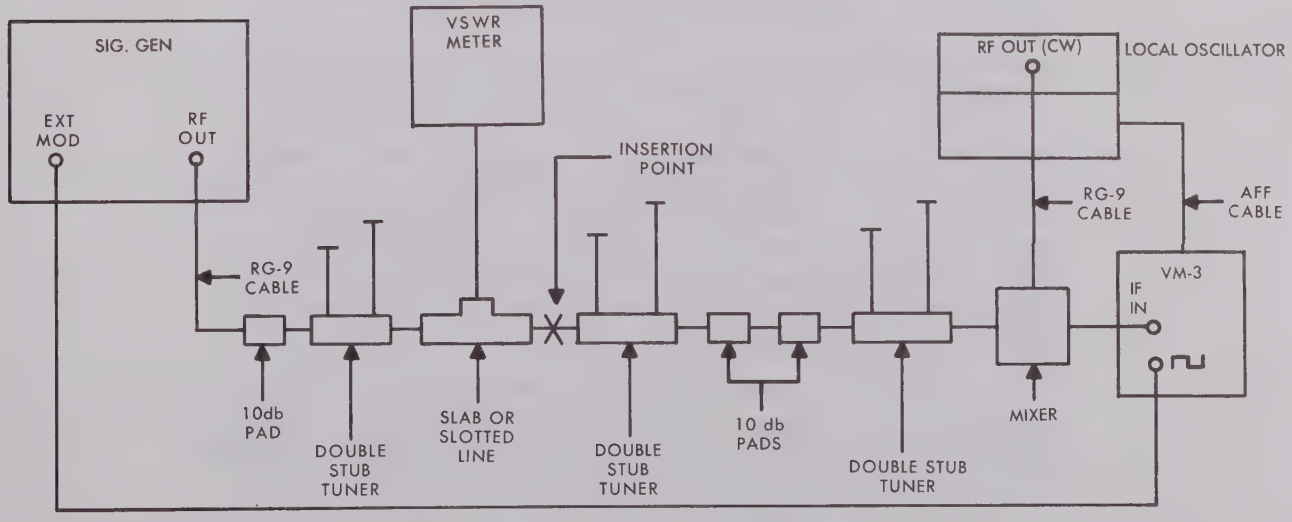


Figure 3.2 VM-3 SET UP FOR COAX INSERTION LOSS MEASUREMENT

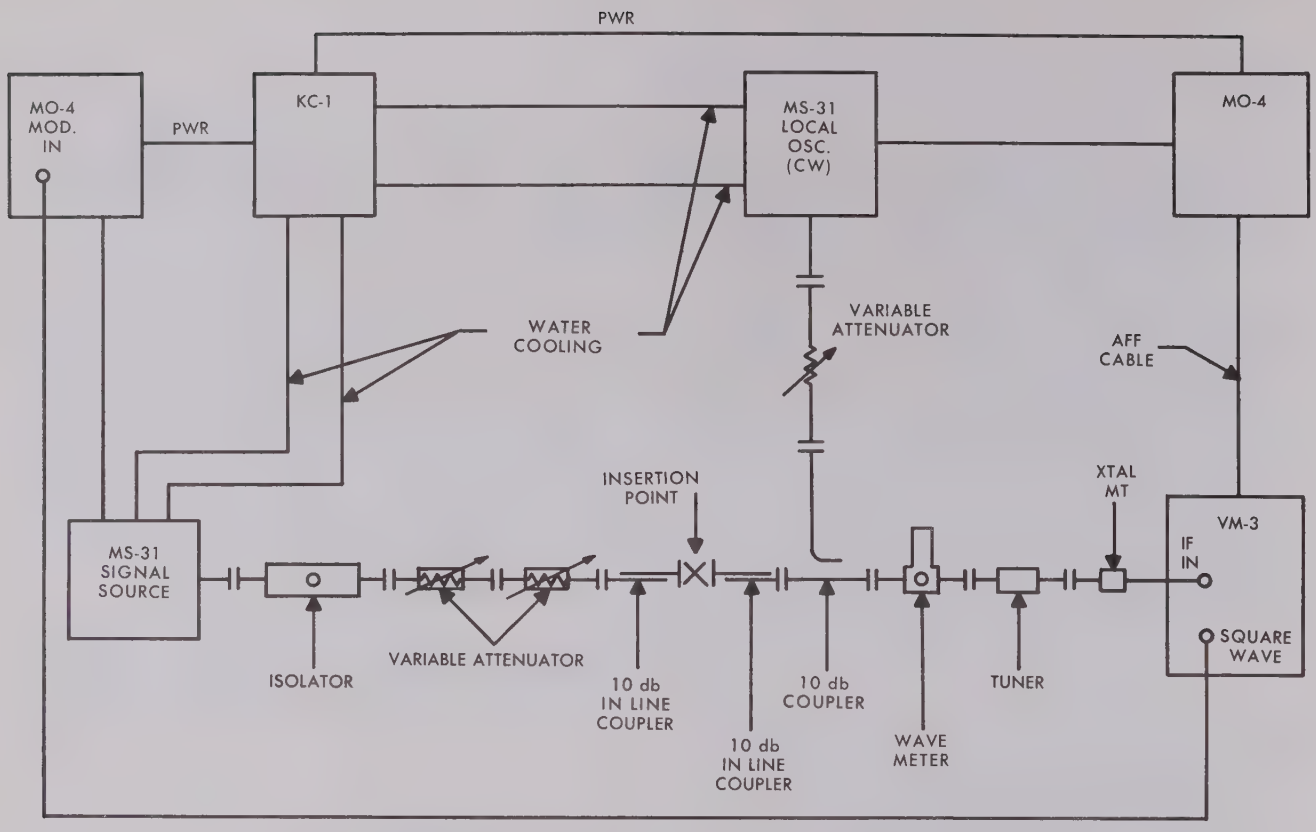


Figure 3.3 SET UP FOR INSERTION LOSS MEASUREMENTS IN X-BAND WAVEGUIDE

3.4.1.2 Procedure:

(a.) Adjust signal frequency for desired operating point with about -20 to -30 dbm input to tuner preceding mixer.

(b.) With the METER FUNCTION switch in the CRYSTAL CURRENT position, adjust the LO power for the recommended XTAL current, with local oscillator frequency ±30 mc from signal frequency. (See Paragraph 3.2).

(c.) Switch FUNCTION SELECTOR to EXTERNAL MODULATION RECEIVER operation, with RECEIVER GAIN set to mid-position.

(d.) Vary local oscillator frequency slightly until a change is observed on FREQUENCY DEVIATION meter. This may also be seen on scope at FM output jack. At this time, a scope indication may be seen at the AM output in the form of a 1 kc square wave (see Figure 3.4). Adjust the RECEIVER GAIN for an amplitude of about 1 volt peak to peak at the AM output jack.

Continue to vary local oscillator frequency until the 1 kc square wave disappears. The FREQUENCY DEVIATION meter should be approximately at mid-scale. Now vary the local oscillator frequency in the opposite direction while observing the FREQUENCY DEVIATION meter. The meter should

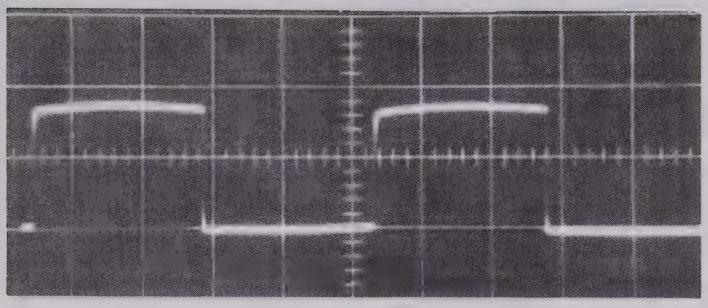


Figure 3.4 1 KC SQUARE WAVE

swing off-scale to one side, then back through zero to an off-scale indication on the opposite side, then back to remain near zero. This indicates that the beat frequency between the signal and local oscillator has been swung completely through the IF bandpass around 30 mc. Now again reverse the direction of change in the local oscillator frequency and, after the meter has completed its first off-scale swing, stop varying the frequency as the meter passes through zero on its way to the opposite off-scale indication. This should place the local oscillator frequency approximately 30 mc from the signal source and approximately in the center of the IF bandpass.

(e.) Place the METER FUNCTION switch in the RECEIVER OUTPUT position and adjust the tuner and VM-3 TUNING control for maximum power transfer, reducing RECEIVER GAIN as required to keep main meter on scale. Occasionally check crystal current.

(f.) During the tuning described in (e), the center frequency should be checked occasionally per (d). Due to the interaction between tuner adjustment, crystal current, and VM-3 TUNING control, the procedure of (e) should be performed slowly and carefully to insure maximum sensitivity.

(g.) Switch FUNCTION SELECTOR to EXT. MOD. ATT. MEAS. and observe AM output wave-form. Adjust the DUTY CYCLE until a symmetrical square wave is produced. Next adjust the setting of the STANDARD ATTENUATOR until a straight line output is obtained. If a balance cannot be obtained, the modulation of the signal source and the VM-3 30 mc reference source are not operating in counterphase (see Figures 3.5 & 3.6). To correct this, place the 0^{o}-180^{o} switch (in the 1 KC SIGNAL FOR MODULATION section) in the opposite position. In the event that the sine wave output is being used to externally synchronize the internal modulation of the signal source, it will be necessary to adjust the FINE PHASE ADJUST and DUTY CYCLE to minimize the spikes present at the AM output (see Figures 3.7, 3.8 and 3.9).

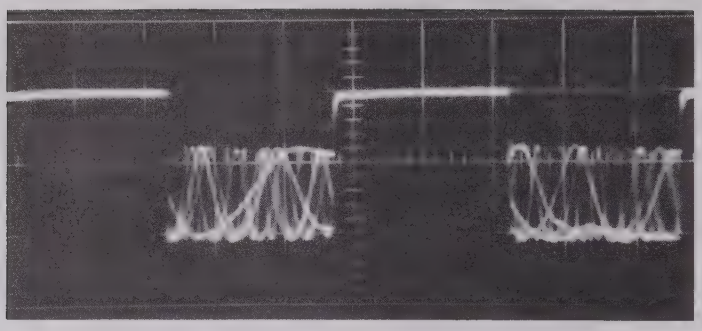


Figure 3.5

MODULATIONS NOT IN COUNTERPHASE
(EXTERNAL MODULATION)

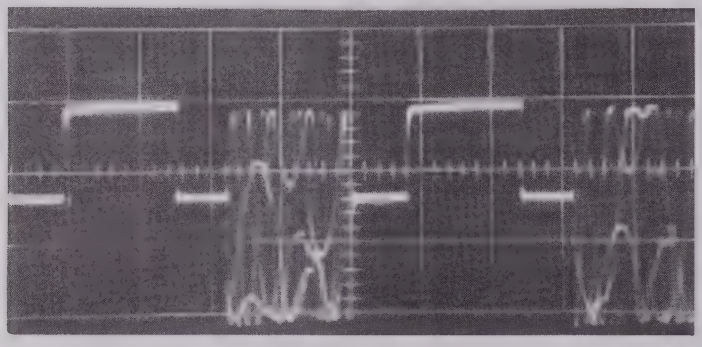


Figure 3.6

MODULATIONS NOT IN COUNTERPHASE
(EXTERNAL SYNCHRONIZATION)

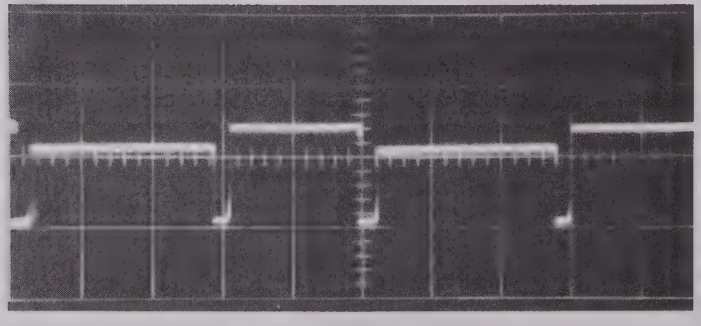


Figure 3.7

MODULATIONS PHASED, BUT IMPROPER DUTY CYCLE
(EXTERNAL SYNCHRONIZATION)

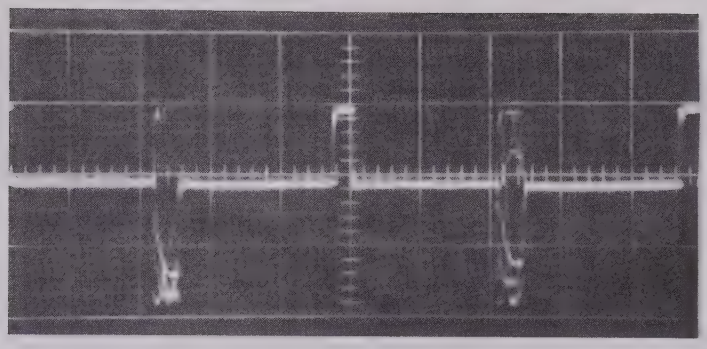


Figure 3.8

DUTY CYCLE CORRECT, BUT FINE PHASE OUT OF ADJUSTMENT
(EXTERNAL SYNCHRONIZATION)

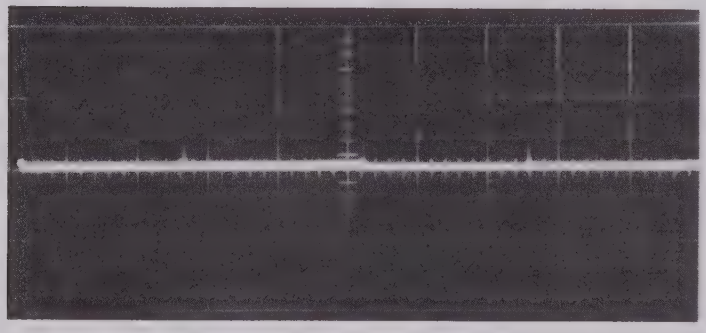


Figure 3.9

DUTY CYCLE AND PHASE CORRECTLY ADJUSTED
(EXTERNAL SYNCHRONIZATION)

(h.) Depress the DEPRESS FOR ZERO ADJUST in the AMPLITUDE BAIANCE section, and zero the AMPLITUDE BALANCE meter with the ZERO ADJUST knob. Release the button and adjust the STANDARD ATTENUATOR for a zero indication on the AMPLITUDE BALANCE meter.

(i.) Observe the FM output and adjust the local oscillator frequency for a straight line indication if possible. FM and frequency deviations will show up as in Figure 3.10, where the 1 kc component is proportional to the frequency deviation.

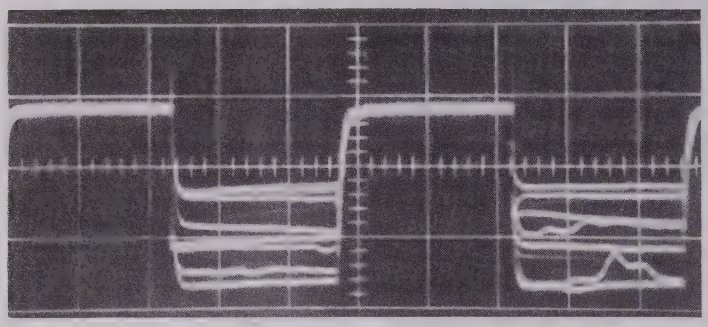


Figure 3.10

FM OUTPUT WITH FREQUENCY DEVIATION AND FM PRESENT

(i.) contd. With both the SLOW GAIN and FAST GAIN controls in the minimum (CCW) position, turn the AFF switch to SLOW. If the FREQUENCY DEVIATION is upset, readjust the local oscillator frequency to correct this. Then switch back to AFF OFF and adjust the AFF EQUALIZER at rear of top chassis for a null on the FREQUENCY DEVIATION meter. Switch back to AFF SLOW and slowly turn the SLOW GAIN clockwise. If the FREQUENCY DEVIATION meter immediately swings away from a balance, the phasing must be reversed by placing the AFF 0^{o}-180^{o} switch (red knob) in the opposite position. Once this has been done, the AFF circuit will hold the signal and local oscillator frequencies to a difference frequency equal to the VM-3 reference source frequency of 30 mc.

If the SLOW GAIN is advanced too far, the resultant feedback may cause "motor-boating," which will be observed on the FREQUENCY DEVIATION meter and at the FM output jack. Keep the SLOW GAIN below this level. If the FM is below 50 kc, the SLOW AFF condition is sufficient for measurement conditions. If the FM is approximately 50 kc or higher, switch the AFF selector to the SLOW AND FAST position, and slowly advance the FAST GAIN control to minimize the FM present.

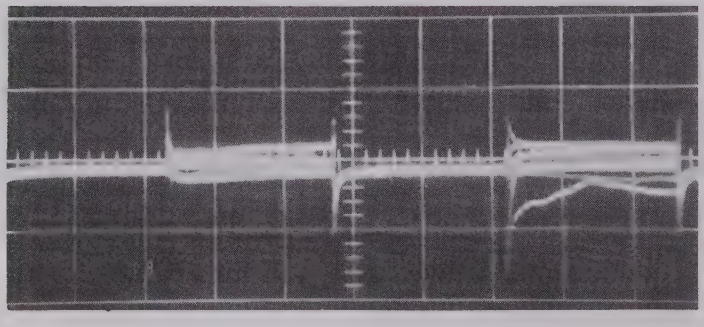


Figure 3.11 SLOW AFF ONLY

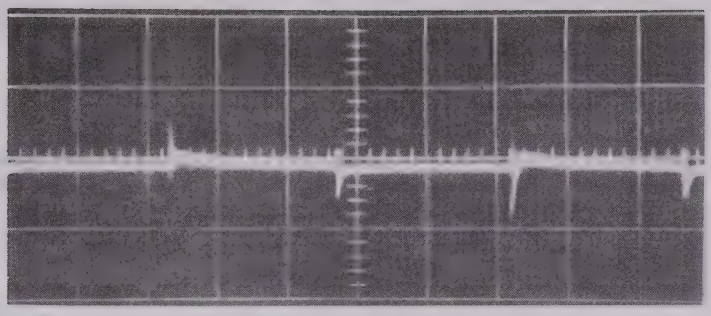


Figure 3.12

SLOW AND FAST AFF

Again, too much FAST GAIN will cause oscillation, so keep this gain below the oscillation point. Note that the AFF circuits will only reduce, NOT eliminate, the undesirable effects of source drift and FM.

(j.) The system is now set up to make attenuation measurements using an externally modulated signal source. In general, the procedure is as follows: Starting at some reference level, adjust the STANDARD ATTENUATOR for an AMPLITUDE BALANCE and note the position on the OPTICAL READOUT (see Paragraph 3.3). Next insert the attenuation to be measured (if the signal rf line is broken for this insertion, the AFF should be turned to OFF before line is broken, and then returned to the ON condition after rebalancing), and null the AMPLITUDE BALANCE using the STANDARD ATTENUATOR. The difference between the reference position and the final position is the attenuation inserted in db. Because of the synchronous detector employed in the AMPLITUDE BALANCE meter circuit, measurements in the noise level may be made. Figure 3.13 shows the AM output indication with a signal level

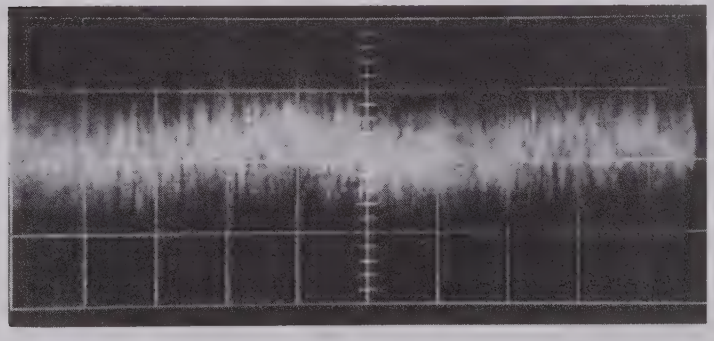


Figure 3.13

AM OUTPUT AT -100 DBM

of -100 dbm and an unbalance of 1.0 db. Scope Sensitivity: 0.2 V/cm. AMPLITUDE BALANCE meter sensitivity is greater than .01 db per division.

(k.) At the low input levels, the effects of rf leakage can create considerable error. To check for leakage, switch the AFF to OFF, set the STANDARD ATTENUATOR to 140 db, and break the signal line, or insert sufficient attenuation to insure that the signal level at the mixer input is -140 dbm or less. If leakage is present at the signal frequency, it will show up as a deflection of the AMPLITUDE BALANCE meter, which may be nulled with the STANDARD ATTENUATOR. The STANDARD ATTENUATOR reading at balance will be an indication of the magnitude of the rf leakage. Generally, the leakage is due to the signal source and subsequent rf connections. To definitely determine that the leakage is from the signal source, switch the source off. If leakage indications persist, look elsewhere for another signal source at the same frequency, or possibly some 30 mc source in the area.

3.4.2 CW

3.4.2.1 RF Setup:

Same as Figures 3.2 and 3.3 except that the source is operated CW. Local oscillator is also operated CW.

3.4.2.2 Procedure:

(a.) With the AFF FUNCTION switch set to the slow position and the SLOW and FAST gain controls in the maximum CCW position, adjust signal frequency for desired operating point with about -20 to -30 dbm input to tuner preceding mixer.

(b.) With the METER FUNCTION switch in the CRYSTAL CURRENT position, adjust the LO power for the recommended current, with local oscillator frequency ±30 mc from signal frequency. (See Paragraph 3.2).

(c.) With ZERO SIGNAL BALANCE (red knob) set to maximum CCW, switch FUNCTION SELECTOR to CW RECEIVER operation, with RECEIVER GAIN set to mid-position.

(d.) Vary local oscillator frequency slightly until a change is observed on FREQUENCY DEVIATION meter. This may also be seen on scope at FM output jack. At this time, a scope indication may be seen at the AM output in the form of a 1 kc square wave (see Figure 3.4). Adjust the RECEIVER GAIN for an amplitude of about 1 volt peak to peak at the AM output jack.

Continue to vary local oscillator frequency until the 1 kc square wave disappears. The FREQUENCY DEVIATION meter should be approximately at mid-scale. Now vary the local

oscillator frequency in the opposite direction while observing the FREQUENCY DEVIATION meter. The meter should swing off-scale to one side, then back through zero to an off-scale indication on the opposite side, then back to remain near zero. This indicates that the beat frequency between the signal and local oscillator has been swung completely through the IF bandpass around 30 mc. Now again reverse the direction of change in the local oscillator frequency and, after the meter has completed its first off-scale swing, stop varying the frequency as the meter passes through zero on its way to the opposite off-scale indication. This should place the local oscillator frequency approximately 30 mc from the signal source and approximately in the center of the IF bandpass.

(e.) Turn the METER FUNCTION switch to the RECEIVER OUTPUT position and adjust the DUTY CYCLE for a symmetrical square wave at the AM output jack. Adjust the tuner and the VM-3 TUNING control for maximum power transfer as indicated on the main meter, reducing the RECEIVER GAIN as necessary to maintain an on-scale indication. Occasionally check each individual diode current to maintain the optimum value (see par. 3.2), and also check the frequency as in par. d above.

(f.) Set the signal source off frequency and insert an additional 120 db attenuation in the signal line. Switch the FUNCTION SELECTOR to the CW ATTENUATION MEASUREMENT position, and set the STANDARD ATTENUATOR to 140 db. Depress the DEPRESS FOR ZERO button, and adjust the AMPLITUDE BALANCE meter for a null, using the ZERO ADJUST knob. Adjust the TUNING control for a "0" indication on the FREQUENCY DEVIATION meter. Adjust the ZERO SIGNAL BALANCE clockwise to obtain a null on the AMPLITUDE BALANCE meter. If the FREQUENCY DEVIATION has varied from zero, readjust the TUNING control and then the ZERO SIGNAL BALANCE until both the AMPLITUDE BALANCE and FREQUENCY DEVIATION meters indicate zero. If the balancing and tuning procedure is not properly performed, the FM output will appear as in figure 3.14. If mixers other than the WE 1507/1508 series are used, the length of the cable between the mixer output and the VM-3 input may have to be changed to obtain balance on both meters.

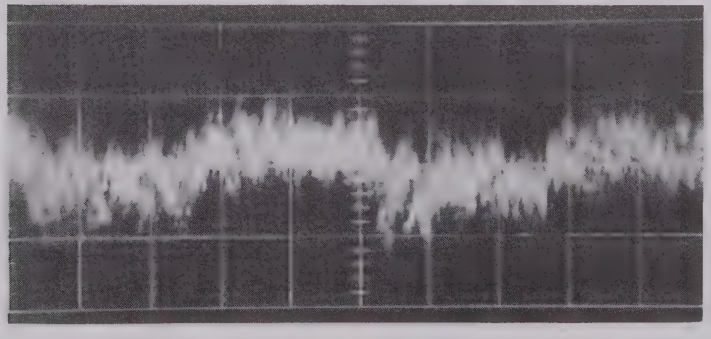


Figure 3.14. FM OUTPUT WITH MISMATCH

If the AMPLITUDE BALANCE and FREQUENCY DEVIATION nulls are not stable, leakage from some other source operating at the same frequency should be investigated.

(g.) Once the stable indications have been obtained, switch the FUNCTION SELECTOR for CW RECEIVER operation, return the mixer input to -30 dbm, and set the signal source on frequency using the following procedure:
Vary signal frequency slightly until a change is observed on FREQUENCY DEVIATION meter. This may also be seen on scope at FM output jack. At this time, a scope indication may be seen at the AM output in the form of a 1 Kc square wave (See figure 3.4). Adjust the RECEIVER GAIN for an amplitude of about 1 volt peak to peak at the AM output jack. Continue to vary the signal frequency until the 1 Kc square wave disappears. The FREQUENCY DEVIATION meter should be approximately at mid-scale. Now vary the signal frequency in the opposite direction while observing the FREQUENCY DEVIATION meter. The meter should swing off-scale to one side, then back through zero to an off-scale indication on the opposite side, then back to remain near zero. This indicates that the beat frequency between the signal and local oscillator has been swung completely through the IF bandpass around 30 Mc. Now again reverse the direction of change in the signal frequency and, after the meter has completed its first off-scale swing, stop varying the frequency as the meter passes through zero on its way to the opposite off-scale indication. This should place the local oscillator frequency approximately 30 Mc from the signal source and approximately in center of the IF bandpass. The local oscillator frequency should not be disturbed during this operation. With a mixer signal input level of -140 dbm or less, any deflection of either null meter is an indication of signal source leakage which must be reduced by proper shielding.

(h.) Adjust the signal level at the mixer input to -15 dbm and adjust the STANDARD ATTENUATOR for a straight line indication at the AM output jack, which should result in a null on the AMPLITUDE BALANCE meter.

(i.) Switch to AFF OFF and adjust the AFF EQUALIZER at rear of top chassis for a null on the FREQUENCY DEVIATION meter. Switch back to AFF SLOW and slowly turn the SLOW GAIN clockwise. If the FREQUENCY DEVIATION meter immediately swings away from a null and a significant change in crystal current is noted, the phasing must be reversed by placing the AFF 0°-180° switch (red knob) in the opposite position. Once this has been done, the AFF circuit will hold the signal and local oscillator frequencies to a difference frequency equal to the VM-3 reference source frequency of 30 mc. If the SLOW GAIN is advanced too far, the resultant feedback may cause "motor-boating", which will be observed on the FREQUENCY DEVIATION meter and at the FM output jack. Keep the SLOW GAIN below this level. Next, switch the AFF SELECTOR to the SLOW AND FAST position, and slowly advance the FAST

GAIN control to minimize the FM present. If the FM increases instead of decreasing (see Figure 3.15), place the 0°-180° switch (in the 1 KC SIGNAL FOR EXTERNAL MODULATION section) in the other position. Again, too much FAST GAIN will cause oscillation, so keep this gain below the oscillation point. Note that the AFF circuits will only reduce, NOT eliminate, the undersirable effects of source drift and FM.

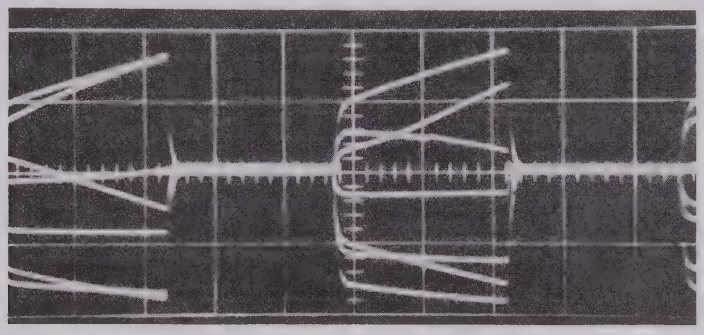


Figure 3.15

FM OUTPUT WITH FAST SIGNAL OUT OF PHASE

(j.) **The system is now set up to make attenuation measurements using a CW signal source. In general, the procedure is as follows: Starting at some reference level, adjust the STANDARD ATTENUATOR for an AMPLITUDE BALANCE and note the position on the OPTICAL READOUT (see Paragraph 3.3). Next, insert the attenuation to be measured (if the signal rf line is broken for this insertion, the AFF should be turned OFF before the line is broken, and then returned to the ON condition after rebalancing), and null the AMPLITUDE BALANCE using the STANDARD ATTENUATOR. The difference between the reference position and the final position is the attenuation in db.**

NOTE

RF LEAKAGE

RF leakage problems can be greatly reduced by using a well-shielded RF signal source, and by avoiding microwave components where RF energy can leak either in or out. Components of this type are slide screw tuners (use E-H Tuner instead), wavemeters (take wavemeter out if necessary), resistive vane variable attenuators, certain mixers, etc.

It is possible, even when using a well-shielded setup, for RF energy to leak directly from the signal source into the VM-3. This leakage signal can then travel into the mixer and return as a 30 mc signal, causing inaccuracies. An excellent remedy for this leakage problem is the insertion of a microwave low-pass filter between the mixer and the VM-3 having a cutoff frequency between the RF signal frequency and 30 mc.

NOTE

AMPLITUDE BALANCE PROBLEMS

It is sometimes possible that with certain mixer-LO combinations, a good zero-signal balance cannot be obtained when following the noise balance procedure (see par. 3.4.2.2f). This happens when the IF output impedance of the mixer is highly reactive, or when the noise from the LO is not pure "white" noise. This problem can be eliminated by varying the length of cable between the mixer output and the VM-3 input. This changes the reactive mixer IF output impedance transformed to the VM-3 input until it is reasonably resistive. A few short cables (preferably semirigid), 6, 8, 10, and 12 inches long, are sufficient since the input tuning of the VM-3 accommodates quite a large range of impedances.

3.5 RECEIVER OPERATION PROCEDURE

3.5.1 EXTERNAL MODULATION:

3.5.1.1 Procedure:

(a.) Follow procedure outlined in Paragraph 3.4.1.2-(a) thru (f).

(b.) The VM-3 is now set up to operate as a receiver with a 1 KC externally modulated signal. The minimum discernible signal should be less than -120 dbm. For receiver operation at low levels, AFF should not be used; instead slightly vary local oscillator or signal frequency for maximum indication.

(c.) For detection of signal levels below -120 dbm, it is desirable to externally modulate or synchronize the signal with the VM-3 1 KC signal and make use of the synchronous detector in the VM-3.

(d.) Turn the FUNCTION SELECTOR switch to the EXT. MOD. ATTENUATION MEASUREMENT position, with the STANDARD ATTENUATOR set to 140 db. Depress the DEPRESS FOR ZERO ADJUST button and zero the AMPLITUDE BALANCE meter using the ZERO ADJUST knob.

(e.) Signal levels down to -130 dbm may now be detected as a deflection of the AMPLITUDE BALANCE indicator. Note that under these conditions the RECEIVER GAIN control is inoperative and sensitivity is controlled by the red SENSITIVITY control in the AMPLITUDE BALANCE section.

3.5.2 CW

3.5.2.1 Procedure:

(a.) Follow procedure outlined in Paragraph 3.4.2.2-(a) thru (e).

(b.) **Turn signal source OFF and adjust the ZERO SIGNAL BALANCE for a minimum on the main meter. Turn signal source ON.**

(c.) The VM-3 is now set up to operate as a receiver of CW signals. The minimum discernible signal should be about -120 dbm. For receiver operation at low levels, AFF should not be used; instead vary local oscillator or signal frequency slightly for maximum indication.

(d.) For detection of signal levels below -120 dbm, switch the FUNCTION SELECTOR to the CW ATTENUATION MEASUREMENT position, and set the STANDARD ATTENUATOR to 140 db. Turn signal source OFF.

(e.) Depress the DEPRESS FOR ZERO ADJUST button and zero the AMPLITUDE BALANCE meter with the ZERO ADJUST knob. Then adjust the ZERO SIGNAL BALANCE knob for a null on the AMPLITUDE BALANCE meter. Turn the signal source ON.

(f.) Signal levels down to -130 dbm may now be detected as a deflection of the AMPLITUDE BALANCE indicator. Note that under these conditions the RECEIVER GAIN control is inoperative and sensitivity is controlled by the red SENSITIVITY control in the AMPLITUDE BALANCE section.

3.6 MODULATION MEASUREMENTS PROCEDURE

3.6.1 AMPLITUDE MODULATION MEASUREMENTS:

3.6.1.1 RF Setup:

See Figures 3.16 and 3.17 (CW only)

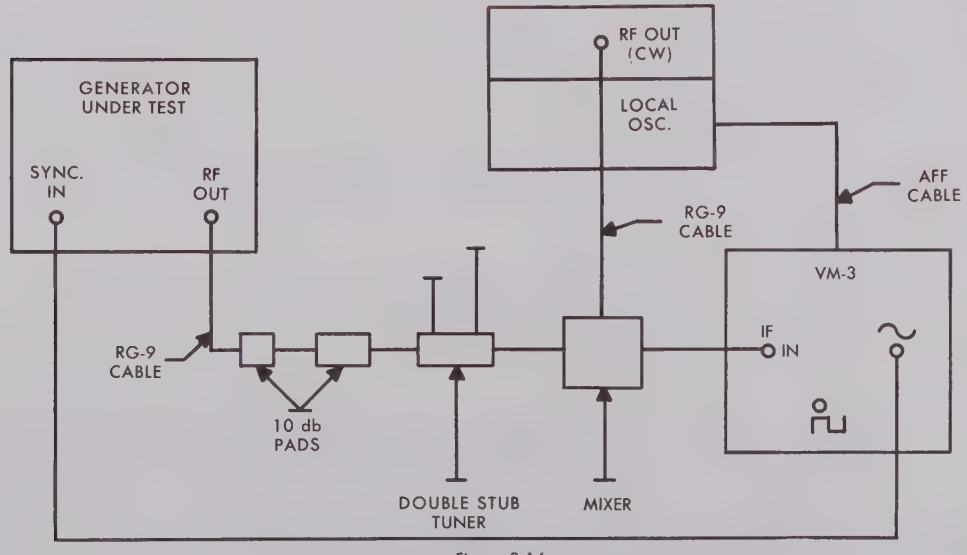


Figure 3.16
TYPICAL SETUP FOR CALIBRATION OF A SIGNAL GENERATOR
(EXTERNAL SYNC. OPERATION)

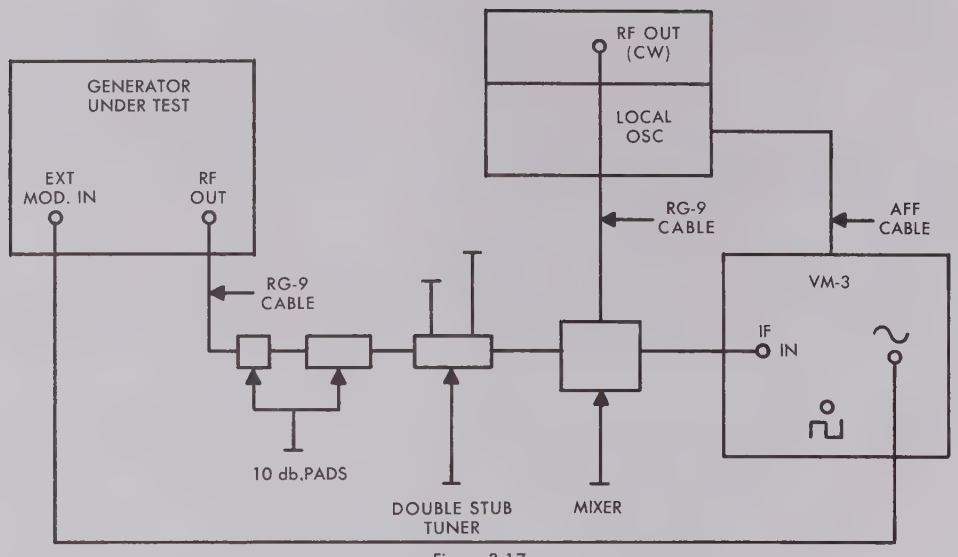


Figure 3.17
TYPICAL SETUP FOR CALIBRATION OF A SIGNAL GENERATOR
(EXTERNAL MOD. OPERATION)

3.6.1.2 Procedure:

Setup to follow same procedure as for CW Attenuation Measurements except that there is no need to adjust "0" SIGNAL BALANCE.

(a.) Adjust the signal level to **between -20 to -50 dbm at mixer input.**

(b.) Set the FUNCTION SELECTOR switch to the AM MODULATION MEASUREMENT position. Set the METER FUNCTION switch to the CAL position. Set the AMPLITUDE MODULATION FREQ. RESP. switch to the BROADBAND position.

(c.) Using the DEPRESS FOR ZERO and ZERO ADJUST, zero the main meter.

(d.) Turn the ADJUST FOR F.S. knob to obtain full scale deflection on the main meter.

(e.) Turn the METER FUNCTION switch to the 100% AM position, and read the main meter.

(f.) If the main meter indication is less than 35% switch the METER FUNCTION switch to the 35% AM position, and read the total AM on the main meter.

(g.) To determine if the AM is symmetrical, check the main meter indication with the AMPLITUDE MODULATION FREQUENCY RESPONSE POS-NEG switch (red knob) in each position. If modulation is symmetrical, the main meter indication will be the same for either position. An example of **asymmetrical** AM is shown in Figure 3.18.

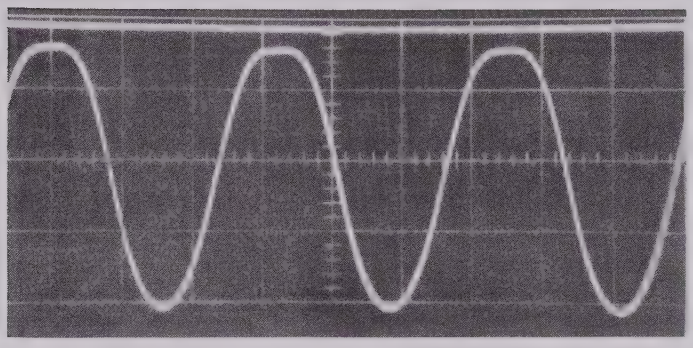


Figure 3.18

AM OUTPUT WITH NON-SYMMETRICAL
AMPLITUDE MODULATED SIGNAL

(h.) By switching the AMPLITUDE MODULATION FREQ. RESP. control to 1000 CPS and 400 CPS positions, the AM due to each of these components will be directly indicated on the main meter.

(i.) The AM wave-form may be observed at the AM output jack.

3.6.2 FREQUENCY MODULATION MEASUREMENTS:

3.6.2.1 RF Setup:

See Figure 3.19

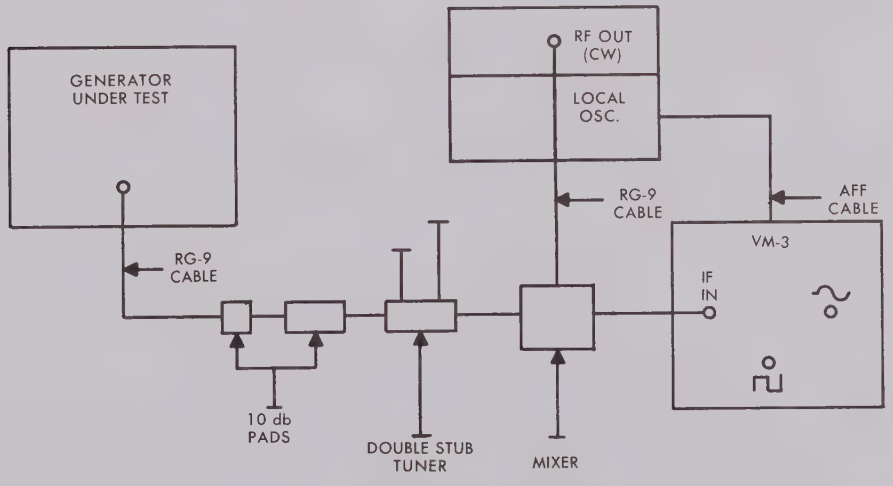


Figure 3.19
TYPICAL SETUP FOR CALIBRATION OF A SIGNAL
GENERATOR (CW OPERATION)

3.6.2.2 Procedure:

Setup to follow same procedure as for CW Attenuation Measurements except that there is no need to adjust "0" SIGNAL BALANCE control.

(a.) Adjust signal level to between -20 to -50 dbm at mixer input. For FM measurements, the AFF circuits are not employed, so switch AFF to OFF and adjust frequency for a null on the FREQUENCY DEVIATION meter.

(b.) Depress the DEPRESS FOR ZERO ADJUST and zero the main meter with the ZERO ADJUST knob.

(c.) With the FUNCTION SELECTOR in the FM MEASUREMENT position, the METER FUNCTION switch in the CAL position, and the POS-NEG switch (red knob) to the NEG position, turn the ADJUST FOR F.S. to yield full scale deflection on the main meter.

(d.) Turn the METER FUNCTION switch to the 1 MC FM position and read the peak to peak FM on the main meter. If indicated FM is less than 100 KC, switch the METER FUNCTION switch to the 100 KC FM position.

(e.) Since the AFF is turned off for these measurements, deviation from the 30 MC difference frequency will appear as an FM signal if the signal is also amplitude modulated. To check for this, return the FUNCTION SELECTOR to the CW ATTENUATION MEASUREMENT position and adjust the zero frequency deviation as in Paragraph (a), then repeat (b) thru (d) above.

(f.) The FM wave-form may be observed at the FM output jack. The calibration at this point is approximately 10 V/Mc, for a peak deviation of ±0.5 mc. See accompanying test data for specific calibration.

NOTE

Since the VM-3 cannot distinguish between FM from the Local Oscillator and FM from the Signal Source, it is recommended that the Local Oscillator used in this setup have low incidental FM.

SECTION IV

THEORY OF OPERATION

4.1 INTRODUCTION

As described in Paragraph 1.4, the Model VM-3 consists of an accurate 30 mc reference source which is stable in both amplitude and frequency, a 30 mc standard attenuator, a noise balance and signal combiner circuit, IF amplifier, discriminator and associated detection and modulation circuits.

In this section of the instruction manual, the theory of operation will be described and each of these citcuits will be discussed in detail. The schematic diagram will be found in the back of this book.

4.2 MIXERS

The mixers used with the Model VM-3 are accessories and are listed in Table 1.3, in Section 1, of this instruction manual. The mixer assembly used must be selected to match the range of the RF frequency to be encountered from the RF source and should produce an output of 30 mc.

If separate local oscillators and mixers are used then the mixer receives two signals; one is the RF signal from the signal generator and the other is from the local oscillator. The local oscillator frequency should always differ from the signal generator frequency by 30 mc. The local oscillator may receive a DC feedback from the automatic frequency follower. This feedback is in the form of an error signal and corrects whatever frequency drift may occur between the IF signal and the standard source frequency. The RF signal generator is either modulated by a 1 KC square wave or operated CW and the signal internally switched in the VM-3. The output of the mixer is applied to the diode switch and noise generator circuit and then on to the signal combiner.

4.3 30 MC SOURCE

The 30 mc source generates the reference 30 mc signal which will be compared with the unknown signal. This crystal controlled oscillator has a frequency accuracy of ±0.002%. It maintains an amplitude stability of ±0.005 db/10 minutes. The source consists of a stable 30 mc crystal which is employed in the grid circuit of the triode section of V-201 which is the oscillator stage. The pentode output section of V-201 functions as a buffer amplifier. The output of V-201 is applied across the primary windings of T-201. The 30 mc signal appearing on the secondary of T-201 is available externally at J-16. The 30 mc output of T-201 is applied to a diode switch CR-201. This diode switch receives a square wave signal from the 1 Kc source which in turn causes the diode to switch to 30 mc source output on and off at a 1 Kc rate. This chopped output is applied to the 30 mc standard attenuator. The 30 mc source operates only when the "FUNCTION SELECTOR" switch is in either of the two Attenuation Measurement positions. During the "Receiver" or the AM or FM "Modulation Measurement" positions of the "Function Selector" switch the B+ to the 30 mc source is turned OFF. This minimizes leakage problems at the low levels. SW-12 on the rear apron of the lower chassis is provided to turn the 30 mc source on while the VM-3 is in the Receiver or Modulation measurement positions.

4.4 30 MC STANDARD PISTON ATTENUATOR

The Model VM-3 uses as the 30 Mc standard substitution attenuator a precision 30 Mc waveguide below curoff attenuator. The principal behind an attenuator of this type is as follows:

An electromagnetic wave of a frequency lower than the lowest cutoff frequency of the waveguide is launched from a moveable launching coil located at one end of the waveguide. This wave is then attenuated exponentially along the distance between the launching coil and a stationary receiving coil. A stationary receiving coil is located at the opposite end of the waveguide from the launching coil. When a waveguide is operated below cutoff an electromagnetic field is set up which decays at a very rapid but constant rate. At a fixed frequency (30Mc) this attenuation rate in decibels is a constant determined by the physical dimensions (diameter) of the waveguide and can be very accurately calculated. Because of its simplicity and the fact that the change of attenuation can be directly related to physical distance measurements, this type of attenuator is an extremely useful and accurate standard.

When attenuation measurements are being made using the Model VM-3, the actual attenuation of the unknown device is determined by very accurately measuring the difference between two settings of the waveguide below cutoff substitution attenuator. In the case of the VM-3, this measurement is made using an optical micrometer which instead of being calibrated in inches is actually calibrated in decibels.

The use of an optical device eliminates the problem of back lash and lead screw calibration which is sometimes found in attenuators of this type. The VM-3 attenuator covers a range of 140 db and consists of an accurately honed stainless steel tube with launching and receiving coils and mode suppressors. The tube supports a below cutoff TE_{11} mode. Separation between the launching and receiving coils is controlled both by a "COARSE" rack and pinion drive and an independent "FINE' control. The optical device reads the movement of the coil to an accuracy of 0.0001". The use of an optical device also eliminates any problems of wear in the drive mechanism. The attenuator and optical readout device are rigidly attached to an aluminum bed casting which is held to the front panel of the VM-3 by five screws. Upon removal of these five screws, the entire attenuator and optical assembly can be easily removed for calibration by NBS for those laboratories that require traceability to National Standards.

4.5 DIODE SWITCH AND NOISE GENERATOR

When the VM-3 is operated with cw rf sources the 30 Mc IF signal which is applied to the input of the VM-3 is internally chopped at a 1 KC rate. The phase relationship between this 1 Kc diode switch and the 1 KC diode switch in the 30 Mc source is such that during one-half of the cycle the signal from the internal 30 Mc standard source is ON, and during the other half of the cycle, the external 30 Mc IF signal is ON. This means that noise from the mixer crystal is present only during the portion of the cycle when the external signal is ON. The absence of this noise signal during one-half of the cycle is not important unless levels below -80 dbm rf are being measured. Below this level, however, the absence of this mixer noise does become very important because the signal and noise are comparable in amplitude. When this is the case, and the operator adjusts the output of the internal 30 Mc attenuator for a balance, if the noise in the two halves of the cycle is not the same, a balance of the detected output does not represent a balance with the signal portion of the input. The error at about -110 dbm is in the order of 1 db.

To overcome this problem of noise when using internal switching, a noise generator and noise balance control have been installed on the Model VM-3*. The circuit employs PL-4 neon bulb (NE-7) in series with a 500k potentiometer. This circuit is adjusted from the front panel by means of the "ZERO SIGNAL BALANCE" control prior to making measurements. This noise injected into the system is present during the half of the cycle when the external source or mixer IF signal is cut off. The internal switching is done with the two diodes CR-101 and CR-102. They are arranged in the circuit so that when one diode receives a forward bias and is ON, the other diode receives a back bias and is OFF.

When CR-101 is ON, the IF signal is passed into the signal combiner and CR-102 cuts off the noise from the internal noise generator. On the next half cycle, CR-101 is OFF and chops the external IF signal off. During this time, CR-102 is ON and passes the noise from the noise generator into the signal combiner. The bias signal for these diodes is a 1 KC square wave. Opposite polarity of these two diodes allows them to operate out of phase. This 1 KC square wave also comes from the 1 KC source in the VM-3 and is in counterphase with the 1 KC square wave that switches CR-201 in the 30 Mc source.

This problem does not exist when the external signal source is being externally modulated, 100 percent with a 1 KC square wave. During this mode of operation, the signal source is turned ON and OFF externally at a 1 KC rate. The CW local oscillator is applied continuously to the crystal and the mixer noise is present all the time and is the same on both halves of the signal modulation cycle.

4.6 SIGNAL COMBINER

The signal combiner is that point in the circuit where the standard 30-mc reference signal is combined with the noise from the internal noise generator. The combined signal is applied to the preamplifier.

4.7 30-MC IF AMPLIFIER AND DISCRIMINATOR

The 30-mc IF amplifier consists of single-tuned stages in cascade with a low-noise cascode input stage, preceded by a cascode nuvistor preamplifier. The IF amplifier serves only to detect a difference between the two signals; its gain is critical only so far as overall range and sensitivity are concerned. The IF amplifier has a bandwidth of approximately 1 mc and a maximum voltage gain of greater than 10^6. To keep the output indicator sensitivity constant over a wide range, AGC is applied to the cathodes of four stages.

The IF amplifier has two video detectors. CR-801 provides AM output which is applied to the AGC circuit, the amplitude balance and metering circuits and to a cathode follower V-401A which is dc coupled to the "AM OUTPUT" connector J-13, located on the front panel. CR-804 provides an output at J-19 for use with an external VSWR indicator or recorder for square law indication over a larger dynamic range than can be had using the front panel meter.

The 30 Mc discriminator circuit consists of V-807 which is a limiter stage and V-808 which functions as a limiter discriminator stage. The output of the discriminator is dc coupled to the front panel through J-14 "FM Output" connector.

* Weinschel Engineering Patent #3,098,968

4.8 AGC AMPLIFIER

The AGC amplifier in the VM-3 receives its AM signal from the IF amplifier through CR-801. This signal is applied to one half of V-402 which is a DC amplifier. The output of the DC amplifier is applied to the other half of V-402 which is a cathode follower. The output of V-402 is fed through an emitter follower transistor Q-401 whose output applies cathode bias to four stages of the IF amplifier to maintain a constant gain.

The AGC reference level is fixed when the FUNCTION SELECTOR switch is in either ATTENUATION MEASUREMENT position. However, when the FUNCTION SELECTOR switch is in either RECEIVER position, the AGC is inoperative and the bias is variable by means of the front panel RECEIVER GAIN control. This enables the operator to see changes in the input level by manually maintaining an on-scale indication on the modulation meter. When the FUNCTION SELECTOR switch is in either MODULATION MEASUREMENT position, the AGC reference level is variable by means of the ADJUST FOR F. S. control which calibrates the modulation meter for full scale deflection.

4.9 AMPLITUDE COMPARATOR

The 1 KC component from CR-801 in the IF amplifier is applied to the amplitude comparator circuit through an amplifier, V-501A, whose output is applied to the grid of V-502 which is used as the synchronous detector. The two deflection plates of V-502 receive a coherent 1 KC reference signal from V-501B which is the reference amplifier whose input is generated by 1 KC source of the Model VM-3. The Meter M-2 which is the "AMPLITUDE BALANCE" null indicator located on the upper left corner of the front panel is connected across the two output plates of V-502 and indicates any unbalance in amplitude between the external 30 Mc IF signal and the internal 30 Mc source reference signal. The use of the synchronous detector in this circuit enables measurements to be made at much lower levels without influence of noise since it responds only to coherent signals. The "Amplitude Balance" meter is adjusted for an electrical zero by depressing the "DEPRESS FOR ZERO ADJUST" button which shorts the grid signal of V-502 to ground and by adjusting the "ZERO ADJUST" control for a null. The "ZERO ADJUST" control adjusts for equal current through both plates of V-502. The sensitivity of the meter is adjusted by means of the "SENSITIVITY" control which is a 500K potentiometer in series with the meter.

4.10 AUTOMATIC FREQUENCY FOLLOWER CIRCUITS

The FM output from the 30 Mc IF amplifier is AC coupled to one half of V-602, which is a signal amplifier, whose output is applied to the other half of V-602 which is a phase splitter. One output from the phase splitter is applied through a 0°-180° switch to the grid of the pentode section of V-604 which is a 1 KC tuned amplifier for the AFF Slow circuit. The output of V-604 is applied to the primary of T-601. The secondary of T-601 in conjunction with diodes CR-603 and CR-604 form the feedback synchronous detector circuit. The output of this feedback synchronous detector is applied between grid and cathode of V-605 which is a DC amplifier. The function of this DC amplifier might be called a variable resistor voltage divider. V-605 receives its plate voltage through a series resistor which forms the fixed element in the voltage divider. The klystron power supply of the RF source whose frequency is being controlled, provides the voltage across this circuit. (See appendix for diagram of the AFF system.) In order to minimize the effects of the incidental FM on the external signal generator the Automatic Frequency Follower circuit has a "SLOW" and "FAST" mode of operation. The fast feedback circuit is added to the output from the slow feedback circuit so that the control signal as applied

to the external repeller circuit has a fast enough response so that it will actually follow the incidental FM signal that appears at the IF input. This reduces the incidental FM present on the IF signal approximately 20/1 which increases the accuracy of the measurement. When the AFF switch is in the "SLOW and FAST" position, the other output of the phase splitter 0°-180° switch is applied directly to V-605, bypassing the Feedback Synchronous Detector. This provides additional feedback to correct or minimize high frequency F.M., whereas the synchronous detector only responds to slow frequency changes.

A second output from the signal amplifier section of V-602 is applied to the grid of the triode section of V-604 which is another phase splitter. The Meter Synchronous Detector circuit which consists of the two diodes CR-601 and CR-602 is connected between the plate and cathode of this phase splitter. The Synchronous Detector outputs are applied to the two grids of V-603 which is a dual triode that functions as a meter amplifier. Meter M-3 which is the "FREQUENCY DEVIATION" meter located on the upper right hand corner of the front panel is connected between the cathodes of V-603.

The reference signal for the automatic frequency follower synchronous detector and meter synchronous detector is generated by the 1 KC source in the Model VM-3. The signal from the 1 KC source is applied to one-half of V-601 which is a reference amplifier. The other half of V-601 is a cathode follower whose output is applied to both Synchronous Detectors.

4.11 METER CIRCUITS

The meter circuits in the Model VM-3 serve several functions which may be selected with the front panel "METER FUNCTION" switch. The first two switch positions are "CRYSTAL CURRENT" " + " and " - ". When the switch is in either of these two positions, a meter shunt is connected across the Modulation Meter" that calibrates the meter to 3 milliamps full scale. The crystal current signal is taken from the input to the diode switch circuit at the input to the VM-3.

The next position is "RECEIVER OUTPUT". In this position the receiver becomes a 30 Mc narrow band receiver which responds to incoming signals from either a cw source or an externally modulated source which means the "FUNCTION SELECTOR" switch must be in either the "CW" or "EXT. MOD." "RECEIVER" positions. By placing the "FUNCTION SELECTOR" switch in either of these positions, the signal as applied to the IF amplifier will be either externally modulated or internally chopped at a 1 KC rate. This allows the diode CR-801 to provide an AM output which is applied through a 1 KC filter to V-701 which is a two stage feedback amplifier. The output of this amplifier is applied to a peak detector CR-703. From here the signal is dc coupled to the meter amplifier circuit V-702. This circuit functions as a dc VTVM with the "Modulation Meter" on the front panel providing the output indication. In the "RECEIVER OUTPUT" position, this front panel readout is provided with a range of 15 db as a square law indicator. The "RECEIVER GAIN" control is in operation during the "RECEIVER" "CW", or "EXT. MOD." position of the "FUNCTION SELECTOR" switch. When the VM-3 is operated in either of the "RECEIVER" positions of the "FUNCTION SELECTOR", the "Modulation Meter" provides the output indication. This indication may become noisy below -110 dbm. Should it be desirable to have a more stable indication down as low as -130 dbm at 30 Mc, switch the "FUNCTION SELECTOR" to either "ATTENUATION MEASUREMENT" position. This activates the synchronous detector circuits

for the "AMPLITUDE BALANCE" indicator and will provide a more stable output indication and increases the sensitivity of the instrument. The internal 30 Mc Standard Source is also turned "ON", therefore, the "STANDARD ATTENUATOR" should be set to 140 db to attenuate the internal signal so that it does not influence the output indication.

The next two positions are for FM measurements and provide a full scale reading of either "100 KC FM" peak to peak or "1MC FM" peak to peak, when the output of the IF amplifier is applied through a divider network to V-701 and then to the peak to peak detector circuit consisting of diodes CR-701 and CR-702. The detected output is applied to the grids of V-702 meter amplifier and on to the meter. In this position the "ADJUST FOR F.S." control is in the circuit and provides a means for adjusting the AGC level for a full scale indication on the "Modulation Meter" in the "CAL." position.

The next two positions are for "AM" measurements and provide a full scale reading of either "35% AM" or "100% AM" full scale. In either of these two positions, the frequency response of the internal tuned circuitry must be selected. If the switch is put into the "1000 CPS or 400 CPS" position, the signal to the meter circuit passes through the proper parallel tuned circuits to allow for the proper frequency response. This output signal is again applied to the feedback amplifier (V-701) where the gain of the feedback amplifier is changed to allow for range changes. The output of the feedback amplifier is applied to the diode peak detector CR-703 and from the diode detector is applied to the meter amplifier V-702. The diode detector allows the operator to check the symmetry of the AM modulation signal which is being measured, by switching the front panel switch from "POS." to "NEG." with the "AMPLITUDE MODULATION FREQ. RESP." control, in the "BROADBAND" position.

The last position is the "CAL." position. When making AM measurements it is used to establish a reference level for full scale deflection. For FM measurements, setting this control for full scale insures that the limiters are operating satisfactorily.

4.12 1 KC SOURCE

The 1 KC source is a bridged "Tee" type oscillator consisting of V-301 and amplifier, V-302. The cathode follower output of V-301 is applied to a sync amplifier V-401B and out through a 100 K potentiometer to J-12 which is the "Sine Wave" output on the front panel of the VM-3. The same output of V-301 is applied to a phase shifting circuit which is also located on the front panel and provides for a phase shift of $\pm 45^{\circ}$ between this signal and the sine wave output on the front panel. The output of the phase shifter is applied to a reference amplifier V-302A, and is also used as a reference signal for the synchronous detectors in both the amplitude and frequency circuits. The output of V-302A is applied through R-319 ("Duty Cycle" Adj.) to V-303 which is a Schmitt trigger and provides a square wave. The square wave output of the Schmitt trigger is applied to V-302B which is a cathode follower whose square wave output is dc coupled to J-11, "Square Wave" output connector located on the front panel of the VM-3. The square wave amplitude adjustment R-326 is also located on the front panel. The output of the cathode follower V-302B is also applied to an emitter follower, transistor Q-301 which provides a square wave

output to the diode switches CR-101 and CR-102 in the diode switch and noise generator circuit. Another output from Q-301 is applied through a 0°-180° phase reversing switch to the internal diode switch CR-201 in the 30 Mc source. This provides the proper phase relationship between the internal 30 Mc source signal and the incoming 30 Mc IF signal.

4.13 POWER SUPPLIES

The power supplies in the Model VM-3 are fairly straight forward supplies which are all solid state with the exception of one 0A2 regulator tube. The power supplies consist of four regulator circuits with outputs of +150 volts, -5.1 volts, +27 volts and -6.3 volts. The +150 volt supply is applied to all circuits and is what would be termed an emitter follower or series element, type of regulator circuit. The -5.1 volt supply provides the AGC reference signal and is regulated by a zener diode. The +27 volt supply is applied to the switching circuits and is also what would be called an emitter follower or series element type of regulator circuit. The -6.3 volt supply provides heater voltage to the IF amplifier with the exception of the limiter and discriminator tubes. It also supplies heater voltage to the 30 Mc source tube. This regulated supply is similar to the 150 and 27 volt supplies with the exception of an additional amplifier to drive the series power transistor. In order to provide high voltage insulation for the tube V-605, used in the automatic frequency follower circuit, it receives its heater voltage from a separate winding on the main power transformer T-901. The power supply main transformer T-901 has provisions for 115/220V, 50/60 cycle operation.

ADDENDUM

In all units of the VM-3 designed for operation at 220 VAC 50 Hz, the audio frequency of the Wien bridge has been adjusted to 995 ±1 Hz (rather than 1000 Hz). This adjustment has been made to avoid a beat with the 20th harmonic of the power line frequency.

SECTION V

SERVICING INSTRUCTIONS

5.1 MAINTENANCE

5.1.1 General

The Model VM-3 is designed to require a minimum of maintenance. No special service tools or test equipment are required. All chassis mounted adjustments have been set at the factory and should not be moved except as directed in this section of the manual.

5.1.2 Replacement of Tubes

The Model VM-3 was designed with sufficient tolerance incorporated in the circuit design to allow for deviations in standard commercial tubes. In general, no special precautions are required for replacement tubes, except that they should have normally low noise levels. The tube complement is listed in Table 5.1. Whenever tubes are replaced the compliance tests (Paragraph 5.2) must be performed.

TABLE 5.1

TUBE COMPLEMENT

Symbol	Type	Use
IF PREAMPLIFIER		
V-101	6CW4	Amplifier
V-102	6CW4	Amplifier
IF AMPLIFIER		
V-801	6922	Amplifier
V-802	6EH7	Amplifier
V-803	6EH7	Amplifier
V-804	6EH7	Amplifier
V-805	6EJ7	Amplifier
V-806	6EJ7	Amplifier
V-807	6AU6	Limiter
V-808	6AU6	Limiter Discriminator
AGC AMPLIFIER		
V-401A	12AU7	Cathode Follower and Sync Amplifier
V-402	6EA8	DC Amplifier & Cathode Follower
AMPLITUDE COMPARATOR		
V-501A	6AU6A	Signal Amplifier and REF. Amplifier
V-502	6AR8	Synchronous Detector
30 MC SOURCE		
V-201	6EA8	Oscillator and Output Amplifier
METER CIRCUITS		
V-701	6EA8	Feedback Amplifier
V-702	5687	Meter Amplifier

(cont.)

TABLE 5.1 (Cont.)

Symbol	Type	Use
1 KC SOURCE		
V-301	6EA8	Oscillator
V-302A	6DR7	Amplifier and Cathode Follower
V-303	6BK7B	Schmitt Trigger
AUTOMATIC FREQUENCY FOLLOWER		
V-601	12AT7	Ref. Amplifier and Cathode Follower
V-602	6EA8	Signal Amplifier and Phase Splitter
V-603	5814	Meter Amplifier
V-604	6EA8	Phase Splitter and Slow Amplifier
V-605	5687	D.C. Amplifier
POWER SUPPLY		
V-901	0A2	Regulator

5.1.3 Replacement of Transistors

The VM-3 was designed with sufficient tolerance incorporated in the circuit design to allow for deviations in standard transistors. The transistor complement is listed in Table 5.2. Whenever transistors are replaced, the compliance tests (Paragraph 5.2) must be performed.

TABLE 5.2

TRANSISTOR COMPLEMENT

Symbol	Type	Use
AGC AMPLIFIER		
Q-401	2N1374	Emitter Follower
1 KC SOURCE		
Q-301	2N697	Emitter Follower
POWER SUPPLY		
Q-901	2N1374	Emitter Follower
Q-902	2N697	Series Regulator
Q-903	2N1544	Series Regulator
Q-904	2N1374	DC Amplifier
Q-905	2N1542	Series Regulator

5.1.4 Replacement of Components

Components should be replaced with parts listed in Table 6.1. Whenever components are replaced, all compliance tests (Paragraph 5.2) must be performed.

5.1.5 115/220 Volt Operation

The Model VM-3 is designed to operate from either a 115 volt or 220 volt nominal 50-60 cps ac line. Unless otherwise specified, this instrument was wired and tested for 115 volt operation prior to shipment from the factory. If there is any doubt as to how this particular instrument is wired, check the voltage marked on the red "CAUTION" label on the rear of the chassis. This unit may be easily changed for operation at either nominal voltage by changing the wiring arrangement on the primary of the main power transformer located on the bottom side of the main chassis. Refer to the schematic diagram, in the back of the book, for arrangement of connections. The main power transformer T-901 is located on the lower chassis at the rear of the instrument. A schematic of the transformer is shown on the back side of the transformer. For operation at 115 volts, terminals 1 and 3 and terminals 2 and 4 should be connected together and the 115 volt line voltage applied between terminals 1 and 4. Access to these terminals may be achieved by removing the VM-3 from its cabinet and laying it on its side so that the terminals will be exposed under the bottom side of the lower chassis. After changing to a different voltage, the compliance tests (Paragraph 5.2) must be performed.

NOTE

Care should be taken to insure that the cooling fan is connected across a single primary winding of T-901 when the VM-3 is set-up for operation at 220V.

5.1.6 Cooling Fan and Filter Maintenance

The motor assembly used in the cooling fan of the Model VM-3 cabinet is lubricated and sealed so that it will provide a life of 3 to 5 years without oiling. However, provisions have been made so that in cases of extreme operating temperature, in the neighborhood of +125°F, the motor may be lubricated using SAE #10 oil which should be injected using a syringe type injector. The lubrication point is clearly marked on the face of the blower motor as seen from the inside of the cabinet.

The screen filter used on the cooling fan may be removed from the rear of the cabinet using a screwdriver or similar tool to snap it out of the plastic holder. The filter is coated with a water soluble adhesive and should be cleaned and recoated every 30 days or when the filter appears to be extremely dirty. In laboratories when a controlled environment exists, it may not be necessary to clean the filter this often. Once the filter has been removed, it should be cleaned thoroughly by flushing with a stream of warm water and allowed to dry. After the filter has thoroughly dried, the filter should be sprayed using a water soluble adhesive. One suggested source of this type of adhesive is as follows: Rotron Filter Coat, Water Soluble Adhesive, manufactured by Rotron Manufacturing Co., Inc., Hasbrouck Lane, Woodstock, New York.

5.1.7 Optical Readout Bulb Replacement

Should it become necessary to change the light inside of the optical readout unit, a spare five-volt lamp is shipped with each VM-3. The spare lamp is clipped to the inside of the unit on the cable that leads to the bulb assembly. The light may be changed in the following manner.

(a) Remove the two Allenhead set screws from the "COARSE" adjustment knob on the standard attenuator.

(b) Remove the two Allenhead set screws from the "FINE STANDARD ATTENUATOR" adjustment knob.

(c) Remove the four 4-40 screws that hold the right hand aluminum face plate to the front panel of the VM-3. This is the aluminum face plate that the "COARSE" and "FINE" controls extend through. The part is marked "STANDARD ATTENUATOR ADJUSTMENT".

(d) Remove the aluminum face plate.

(e) The spare bulb can now be seen clipped to the power cord that runs to the optical readout device. The bulb is held in place by a socket which is screwed into the side of the optical readout device. This socket must be unscrewed in a counter-clockwise direction in order to remove the bad bulb. Once this has been removed the new bulb may be replaced and the entire procedure reversed to reassemble the front panel on the VM-3.

5.1.8 Optical Readout Alignment and Maintenance

Under normal conditions, the optical readout device will not require maintenance. However, under adverse conditions or if the filter on the cooling fan is allowed to operate over long periods of time without cleaning, the rack and pinion drive may become dirty and stiff instead of moving smoothly. Should this happen, the VM-3 may be removed from the cabinet and the upper chassis of the VM-3 raised and snapped into its upright position as shown in Figures 5.1 and 5.2, and explained in Paragraph 5.2.4 (a) and (b), so that access to the rack and pinion is available. The ways on the mechanism may be cleaned using a soft rag and a suitable solvent and lightly re-oiled using SAE #10 oil. The unit may then be replaced in its cabinet ready for operation. Because the optical unit provides a magnification of 22 power, small particles of dust and dirt which may accumulate on the stainless steel scale will appear to be very large on the face of the optical readout device. This dirt may interfere with the reading as indicated on the face of the optical unit. Should this be the case, the VM-3 should be removed from its cabinet as described above and the scale cleaned very gently using a very soft cloth and dirt solvent, such as toluene or alcohol.

NOTE

Be extremely careful when adjusting the readout device so that the readout device and scale do not come in contact with each other. This would result in severe damage to the fine divisions on the scale face. Caution should also be observed in the cleaning of the scale.

In order to check the alignment, the VM-3 should be plugged into a 115 volt AC line and the main power ON-OFF switch set to the ON position. The "FUNCTION SELECTOR" switch should be set to either "ATTENUATION MEASUREMENT" position. This turns on the light inside the optical device so that the scale divisions may be read.

The spacing between the readout device and the face of the scale is approximately 0.135". This spacing should be the same over the entire length

of travel of the scale. In some extreme cases, shimming between the scale and the scale mounting bracket may be necessary, should the scale or scale mounting bracket become bowed. This 0.135" dimension need not be measured but rather the following steps should be followed to focus the scale image. If this dimension is off, the results from the following steps will indicate that adjustments are required.

(a) Turn power "ON" and set "FUNCTION SELECTOR" to either "ATTENUATION MEASUREMENT" position. Rotate the outer knurled ring of the readout device until a reading of "0.000 db" is obtained in the lower window of the readout device.

(b) Move the **"COARSE" adjustment** toward either extreme position where a reading may be taken. An image should be seen in the large upper window of the readout device face. A close look at the scale will show a small beam of light being projected from the readout device to the face of the scale. This beam of light should be projected on the portion of the scale that contains the numbers and divisions.

(c) The readout device may now be adjusted if necessary by means of the dovetail clamp to bring the image into sharp focus. This is done by moving the readout device either closer to or farther away from the scale.

(d) When the proper adjustments have been made, the scale divisions should be visible only in the narrow center window of the readout device face and the scale numerals will be visible in the large upper window of the readout device face.

(e) These conditions should be checked at both ends of the scale. In the event that the scale divisions do not line up exactly in the narrow center window, the scale mounting plate has sufficient tolerances in the mounting holes to allow raising or lowering of the scale at either end until proper tracking is achieved.

(f) After all adjustments have been made for proper tracking and focus, the attenuator should be set to either extreme position.

(g) With the outer knurled ring of the readout device adjusted for a reading of 0.000 db in the lower window of the readout device face, one end of the double line Archimedes spiral should be across the narrow center window on the face of the readout device.

(h) Next, adjust the attenuator by rotating the **"FINE" adjust knob until** one of the divisions of the scale, which is visible in the narrow center window, moves exactly into the center of the double line Archimedes spiral.

(i) Now rotate the knurled outer ring of the readout device until a reading of 1.000 db is obtained in the lower window on the face

of the readout device. The opposite end of the double line Archimedes spiral should now exactly bracket the other scale division that was visible in the narrow window. This is the division that appeared to be about one-half inch to the right of the first division that was bracketed. If this is not the case, the readout device should be moved closer to or farther away from the scale until one of the scale divisions is centered in one end of the double spiral when the reading in the lower window is 0.000 db and the other division is centered in the other end of the double spiral when the reading in the lower window is 1.000 db. Check this at both extreme ends of the scale as well as in the middle.

NOTE

If the two scale divisions appear too far apart, the readout device should be moved away from the scale. Conversely, if the scale divisions appear too close together when checked with the double spiral lines, the readout device should be moved closer to the scale. Optimum focus should also be apparent when the two divisions are perfectly centered.

5.1.8.1 Adjustment of Spring Tension

Under normal conditions, spring tension adjustment of the piston attenuator drive unit is not necessary. However, if excessive backlash in the FINE control is experienced it may be necessary to adjust this tension.

The spring tension adjustment screw is located directly below the drive unit. An increase in tension is achieved by rotating the screw in a clockwise direction. This screw should be adjusted only after the FINE control has been turned fully counterclockwise. After the tension has been adjusted, the fine drive should be checked for backlash. The tension should not be increased any more than necessary.

5.2 COMPLIANCE TESTS

5.2.1 Introduction

The compliance tests verify that the equipment is still performing according to the specifications listed in Table 1.1. These tests should be performed every six months. The equipment should be allowed to warm up for one hour prior to conducting these tests.

Adjustment procedures are given wherever required at the end of each compliance test so that the proper adjustments may be performed in conjunction with the compliance test.

5.2.2 Equipment Required

The equipment recommended for performing the compliance tests is listed in Table 5.3.

TABLE 5.3

TEST EQUIPMENT REQUIRED

Equipment	Manufacturer	Model
Variac w/Ammeter	General Radio	W10MT3A
VOM	Triplett	630A
DC VTVM	Kintel	Microvoltmeter
AC VTVM	Hewlett-Packard	400D
VSWR Meter	**Weinschel**	**1800**
Oscilloscope	Tektronix	545
Oscilloscope Plug-in	Tektronix	53/54C
Sweep Generator	Telonic	SM2000
Signal Generator	Hewlett-Packard	608D
Signal Generator (Audio)	Hewlett-Packard	200CD
Signal Generator	Hewlett-Packard	612
Signal Source	Weinschel	MS-8
Power Supply	Weinschel	MO-3
Frequency Counter	Hewlett-Packard	524D
Frequency Counter Plug-in	Hewlett-Packard	525A
Mixer (1 Gc)	Weinschel	1507A
DC Source 0-3 VDC	NOTE 1	
RF Peak Detector	NOTE 1	
Slab Line	**Weinschel**	**1000R**
3 each Double Stub Tuners	Weinschel	DS-109L
3 each 10 db Attenuators	Weinschel	50-10
20 db Standard Attenuator	NOTE 2	
40 db Standard Attenuator	NOTE 2	
60 db Standard Attenuator	NOTE 2 } **Weinschel Model 50S**	
80 db Standard Attenuator	NOTE 2	
100 db Standard Attenuator	NOTE 2	
1 each 50 Ω Termination	Weinschel	535MN
30 Mc Piston Attenuator	Weinschel	PA-2

NOTE 1: These items to be made from Figures 5.5 and 5.6.

NOTE 2: These attenuators should be Standards, preferably with Calibration Certificates **at 1 Gc.**

5.2.3 Power Supplies

The four power supplies of the Model VM-3 should be checked for their nominal values even though only one supply is adjustable. The test points for the four supplies are located on the printed circuit board on the top, right-hand side of the lower chassis as shown in Figure 5.1. The ripple of these supplies may be checked by connecting the vertical input of an oscilloscope to the various test points. By varying the time base of the oscilloscope, the frequency of the ripple may be determined.

The following nominal voltages and ripples should be measured for a constant AC line voltage of 115V:

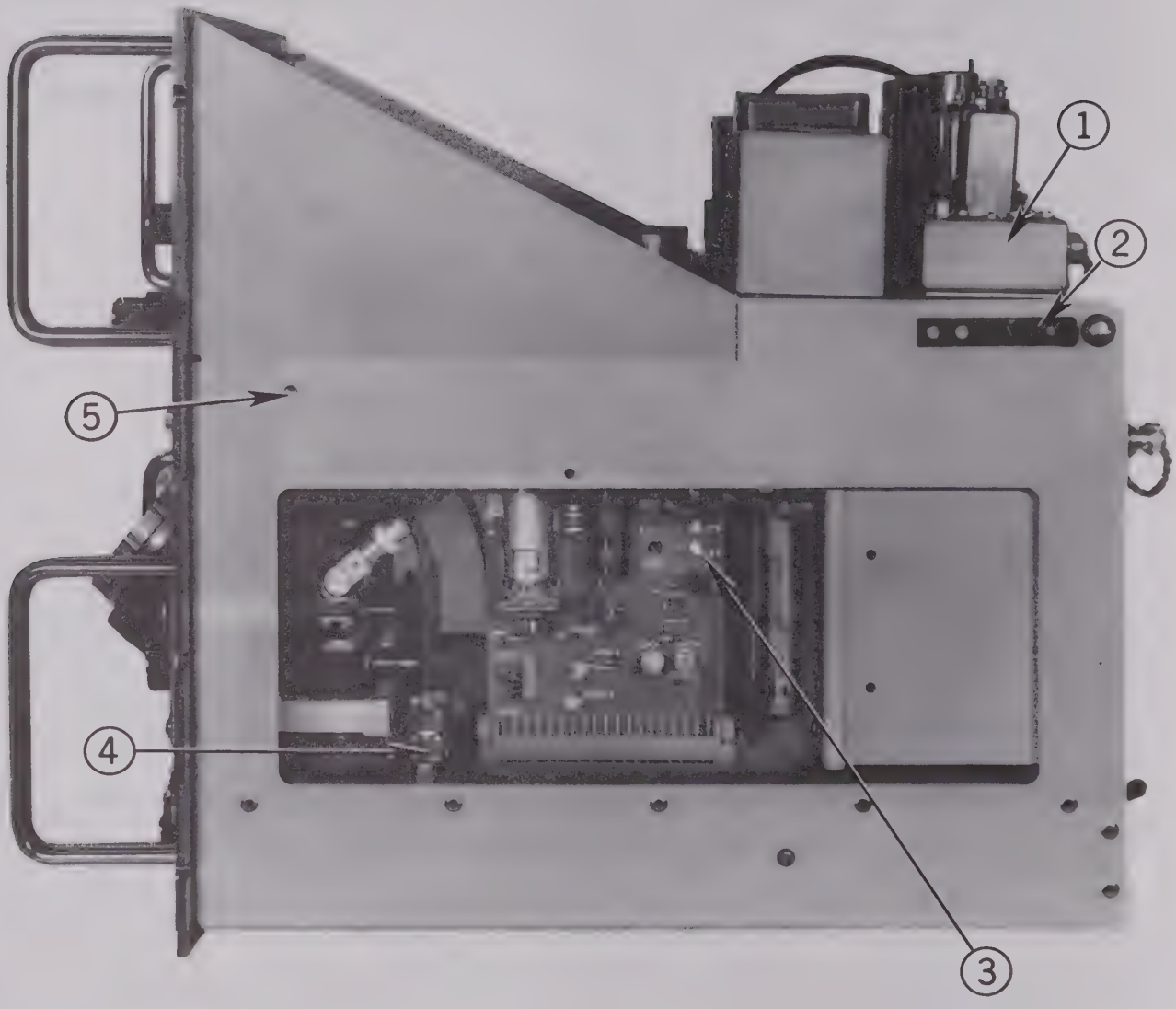


Figure 5.1. Side View, Model VM-3, Cabinet Removed

1. IF Amplifier
2. Position Locking Pin
3. Test Points, Power Supplies
4. P-903
5. Locking Screw (One each side)

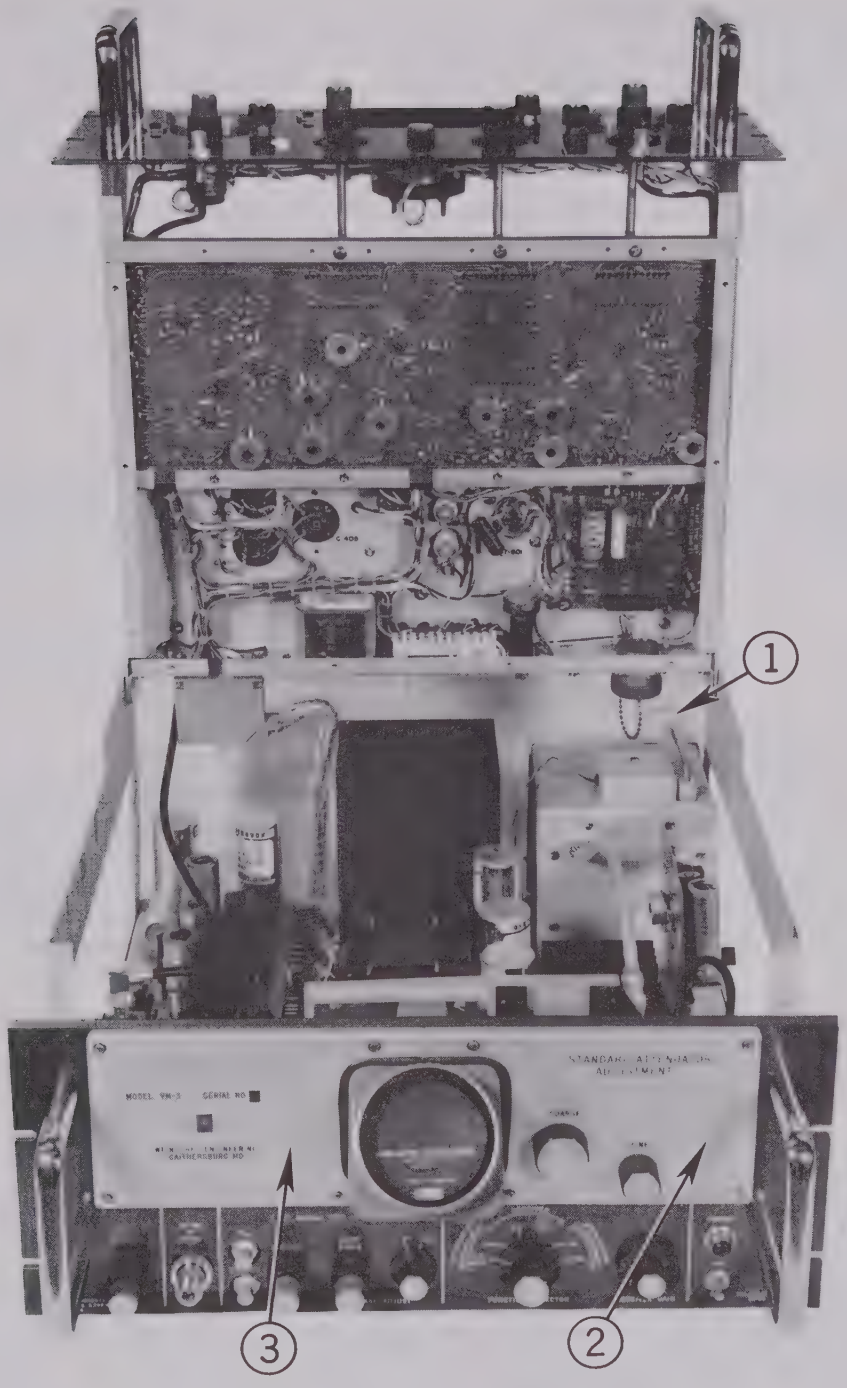


Figure 5.2. Three Quarter View, Model VM-3, Upper Chassis Raised

1. J-16 30 Mc Output
2. Removable Aluminum Faceplate
3. Removable Aluminum Faceplate

Voltage	Ripple (p-p)
+150 VDC, ±5 VDC	70 MV
+27 VDC, ±3 VDC	30 MV
-6.3 VDC, ±0.3 VDC (Adjustable)	30 MV
-5.1 VDC, ±0.8 VDC	30 MV

Should the -6.3 VDC supply require adjustment, it may be adjusted using R910, screwdriver adjust, located adjacent to the -6.3 VDC test point (See Figure 5.1).

NOTE

Do not adjust -6.3 VDC if it is within the above tolerance

The regulation of these four supplies may be checked by varying the line voltage between 105 and 125V AC. The permissible deviations from the values at a line voltage of 115V are:

+150 VDC, ±3 VDC
+27 VDC, ±0.6 VDC
-6.3 VDC, ±.1 VDC
-5.1 VDC, ±0.3 VDC

5.2.4 30 MC Attenuator Accuracy and Linearity

A Weinschel Model PA-2 Precision 30 Mc Waveguide Below Cutoff Attenuator which has a calibration traceable to the National Bureau of Standards is used as a standard for this measurement. (Equipment should be set up as shown in Figure 5.3 with SW-12 in ON position). The VM-3 controls are set for CW Receiver operation. With the PA-2 set to 40 db adjust the VM-3 "TUNING" control for a maximum indication on the receiver meter, reducing "RECEIVER GAIN" control as required. Turn SW-12 OFF.

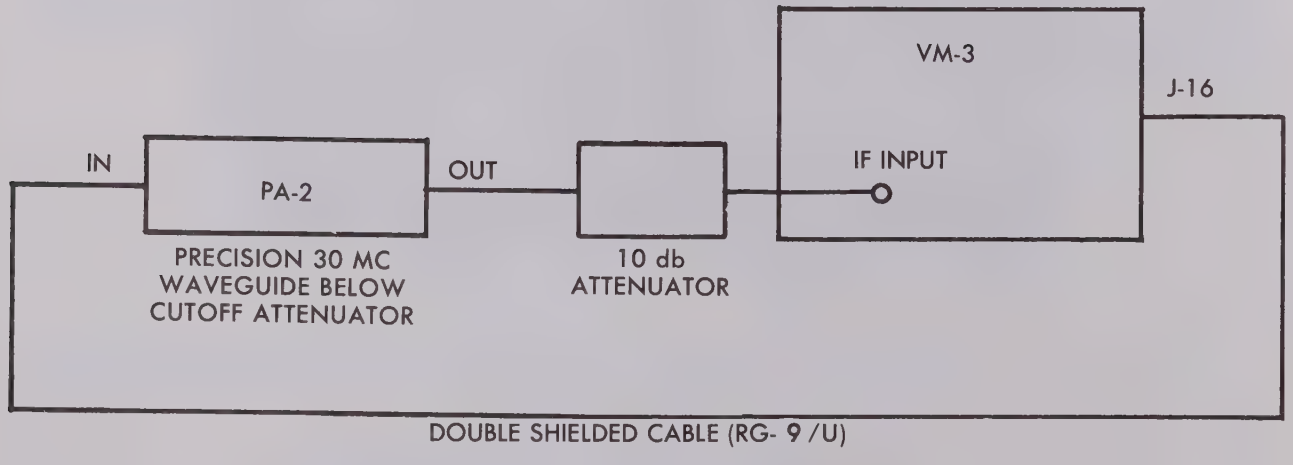


Figure 5.3
SETUP FOR CALIBRATION OF 30 MC ATTENUATOR

Set the FUNCTION selector to the CW ATTENUATION MEASUREMENT position. With both attenuators set to 140 db, adjust the ZERO SIGNAL BALANCE and TUNING controls for a null indication on both AMPLITUDE BALANCE and FREQUENCY DEVIATION meters. The ZERO SIGNAL BALANCE control should be operated as close to the CCW end as possible for this balancing operation. The procedure used for this operation is the same as the one described under "CW attenuation" measurements in Section III of this manual.

Set the VM-3 to approximately 12.0 db and null the AMPLITUDE BALANCE meter using the PA-2. Next set the PA-2 to the nearest traceable calibration point and again rebalance the system, this time using the VM-3 attenuator. The reference is now established and the calibrated increments of the PA-2 may now be compared with the VM-3 attenuator. The procedure is to set the PA-2 to the desired calibrated mark and null the system using the VM-3 attenuator. The two attenuators should track each other within the specified accuracy over the linear range. The VM-3 attenuator should be checked until a setting of at least 115 db is reached on the VM-3 or until a balance is no longer obtainable. It is recommended that the attenuator be checked in increments of less than 10 db so that the Archimedes spiral of the optical device may also be checked.

If Spare interchangeable piston attenuators are used, (See Fig. 6.5) the entire attenuator and readout device may be removed from the VM-3 and replaced with a calibrated unit. The assembly may be removed by the following method:

(a) Remove the VM-3 from the cabinet making sure the cooling fan is first unplugged and the 1/4 turn fastener on the rear of the cabinet which secures the lower chassis has been loosened.

(b) After removing the two locking screws (See Fig. 5.1) raise the upper chassis to the upright position (See Fig. 5.2) making sure it is locked into place.

(c) Disconnect the two TNC connectors located one at either end of the attenuator assembly, and unplug the light from J-3 .

(d) Remove the COARSE and FINE adjust knobs from the attenuator by loosening the two Allenhead set screws in each knob.

(e) Remove the two halves of the Aluminum Face Plate by removing the 4 each 4-40 screws that secure each half to the front panel.

(f) Remove the 5 each 8-32 screws from the front panel that secure the bed casting to the front panel. The entire assembly may now be removed from the VM-3 for external calibration or replacement.

To replace the unit, reverse this procedure and check the Optical Readout alignment as described in paragraph 5.1.8.

5.2.5 Reference Oscillator

Connect J-16 (See Fig. 5.2) through a 3 foot length of RG-58/U cable to the oscilloscope vertical input, and turn equipment ON. At this time the oscilloscope display should appear similar to Fig. 5.7. Switch the FUNCTION

SELECTOR to the RECEIVER EXT. MOD. position, and turn SW-12 ON. Note that the 1-kc modulation observed at J-16 disappears and the output is a 30-mc CW signal.

Connect the scope to J-16 using a cable with a BNC tee at the scope input. Terminate the open arm of the tee in 50Ω. Turn SW-12 OFF. Tune L-202, the oscillator coil, until 30-mc oscillations are observed on the scope. Tune T-201 for maximum square-wave modulation of the RF signal. See figure 5.7. Tune the oscillator coil slug counterclockwise until the 30-mc pattern is lost from the scope. Retune the coil clockwise until the pattern returns, and add two more turns clockwise.

Remove the cable from J-16 and the tee from the scope. Connect the tee to J-16. Turn SW-12 ON. Measure the output at the open arm of the tee with the RF VTVM and set R-208 for 1 volt rms.

Reconnect the cable to J-16 and the terminated tee to the cable. Connect the tee to the HP-524D counter and the HP-525A plug-in unit. Set the mixing frequency of the counter to 20 mc (add 20 mc to the counter indication to find the true frequency of the source). Tune L-204 for 30 mc ± 500 cps. If the frequency cannot be obtained, return L-202.

Remove the cable (with tee) from the counter and reconnect it to the scope. Turn SW-12 OFF. Recheck the adjustment of T-201. Turn SW-12 ON, disconnect the tee from the scope, and connect the tee to J-16. Recheck with the RF VTVM for 1 volt rms.

Remove the tee from J-16 and replace with the 50Ω termination. Turn SW-12 OFF and set the FUNCTION SELECTOR switch to the CW ATTENUATION MEASUREMENT position. Using the HP-608D, apply a CW 30-mc signal through a type N tee to the VM-3 IF input. Terminate the open arm of the tee in 50Ω. Adjust the output of the 608D for an input of -23 dbm to the VM-3. Adjust the piston attenuator for a null on the AMPLITUDE BALANCE indicator. At this point the optical readout should indicate a level of 15 ± 3 db.

To check the 30 MC source stability with changes in line voltage, set the FUNCTION SELECTOR to the RECEIVER EXT. MOD. position and switch SW-12 to the 30 MC ON position.

Connect the rf peak detector (See Fig. 5.5) to the output of the piston attenuator. Connect the DC VTVM and variable DC sources as indicated in Fig. 5.4, with the DC source voltage initially set to "0". AC line voltage to the VM-3 should be set to 115V.

Adjust the piston attenuator for an indication of about 0.5 VDC on the DC VTVM. Now increase the variable DC source output until the DC VTVM indicates "0", increasing the DC VTVM sensitivity as a null is approached. Select a DC VTVM range where a .005 db change in the piston attenuator position yields about half scale deflection. Adjust the piston attenuator for a null on this range and change the line voltage from 115V to 105V. Readjust the piston attenuator for a null on the DC VTVM and record the change in position required. This change should be less than .005 db. Return the line voltage to 115V and readjust the piston attenuator for a null. Change the line voltage to 127V and repeat the nulling process, recording the change in piston attenuator position. This change should also be less than .005 db.

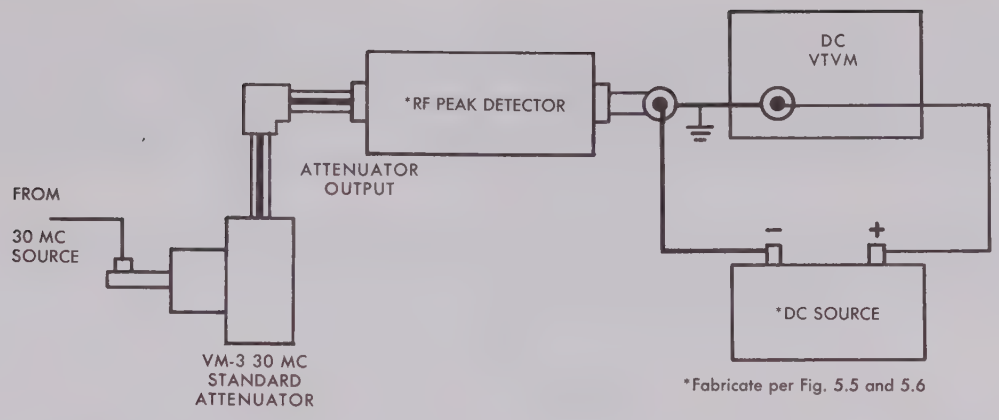


Figure 5.4
BLOCK DIAGRAM FOR 30 MC SOURCE STABILITY TEST

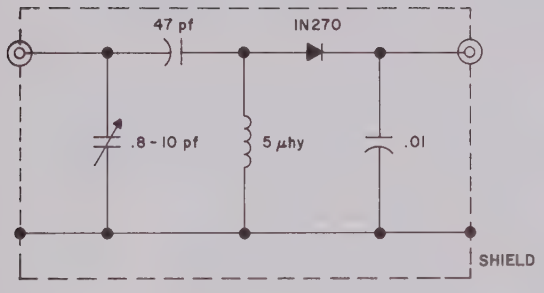


Figure 5.5
RF PEAK DETECTOR

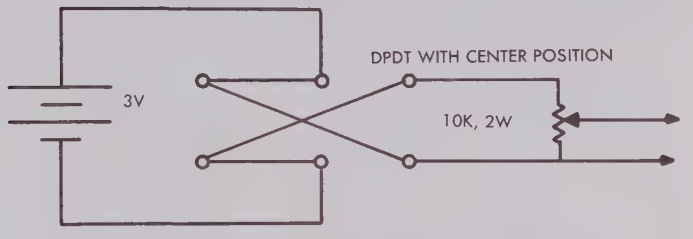


Figure 5.6
O-3V DC SOURCE

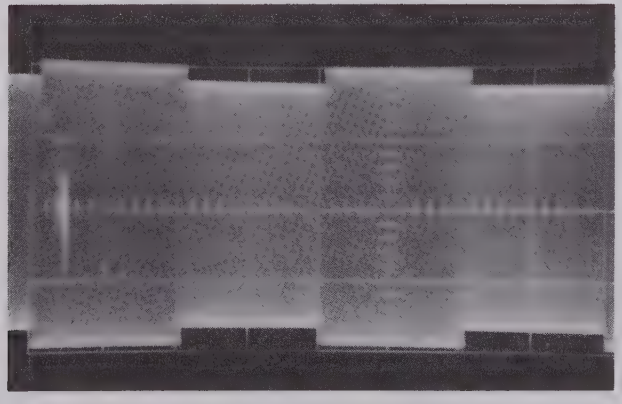


Figure 5.7 30 MC Output At J-16

Restore line voltage to 115V and null the DC VTVM with the piston attenuator. Wait 10 minutes and readjust the piston attenuator for a null on the DC VTVM, recording the change in piston attenuator position required. This should be less than .005 db. It may be necessary to wait several minutes after returning the line voltage to 115V before beginning the 10 minute measurement to be sure the system has stabilized. For this test, the line voltage should be regulated.

Remove the detector from the piston attenuator, reconnect the piston attenuator output cable, and turn SW-12 to the OFF position.

NOTE

These tests could be performed with the rf peak detector connected to the 30 MC source output J-16, but the output voltage change would have to be converted to a db value since the piston attenuator would not be in the circuit.

5.2.6 IF Amplifier

5.2.6.1 Center Frequency

Set up the equipment as shown in Fig. 5.8. Set the modulation of the 608D to 50%. Set the VM-3 METER FUNCTION selector to RECEIVER OUTPUT. The FUNCTION SELECTOR to RECEIVER EXT. MOD.

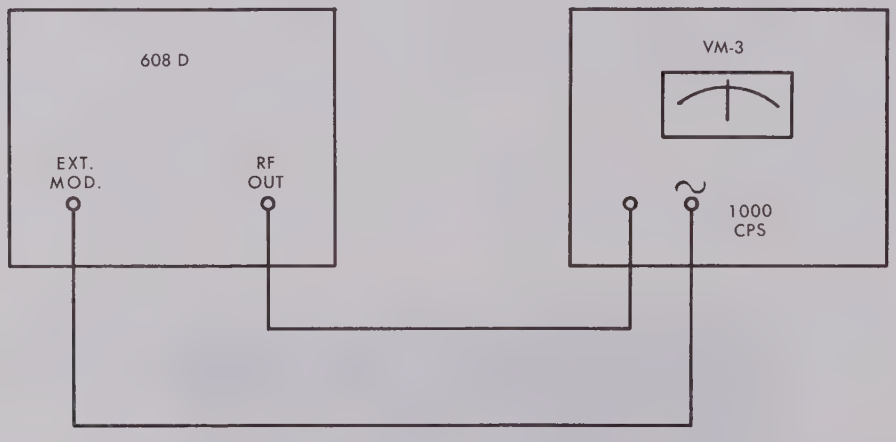


Figure 5.8
SETUP FOR IF AMPLIFIER CENTER FREQUENCY TEST

Adjust the output attenuator of the 608D to -100 dbm. Adjust the RECEIVER GAIN control of the VM-3 to give a mid-scale indication on the output meter. Vary the frequency of the 608D until the output meter peaks, adjusting the gain of the receiver to keep a mid-scale indication, observe the frequency dial setting of the 608D. This should be about 30 Mc.

5.2.6.2 Gain

To measure the IF Amplifier gain, connect the HP-608D directly to the VM-3 30 Mc IF Input through a Type N Tee, with a 50Ω termination on the open arm of the tee. Operate the HP-608D in the CW mode at a frequency of 30 Mc. Set the VM-3 FUNCTION SELECTOR to the RECEIVER EXT. MOD. position.

Connect a DC VTVM to J-19. With the HP-608D output attenuator set to -125 dbm, turn the VM-3 RECEIVER GAIN control to indicate a video output voltage of -2 VDC. (The HP-608D output meter should indicate at the "set-point"). Increase the HP-608D output with the output attenuator until the video output is exactly -4 VDC. Note the output voltage on the attenuator dial.

Calculate the maximum gain as:

$$A_{max} = 20 \log \frac{4}{v}$$

Where v = HP-608D output voltage previously noted.
Record this value, which should be at least 120 db.

5.2.6.3 Bandwidth

Set the H-P 608D output attenuator to indicate -90 dbm. Adjust RECEIVER GAIN until the DC VTVM indicates -1.41 VDC and note the frequency deviation on each side of 30 MC at which the video output is reduced to -1.00 VDC. These deviations should be about 500 KC on each side of 30 MC. Record the sum of these deviations as the IF amplifier bandwidth, which should be 1 MC ± 200 KC.

5.2.7 IF Input Tuning and Amplifier Alignment

The IF Amplifier and Discriminator of the VM-3 should not require adjustment under normal conditions and should not be disturbed or any adjustment made **unless,** as a result of tube or component changes, the above compliance tests indicate that the unit does not meet specifications.

With all tubes in place and both bottom covers secured, connect the HP-608D through a 20-db pad and type N tee to the VM-3 input. Terminate the open arm of the tee with 50Ω. Set the 608D output attenuator for -90 dbm into the VM-3. Connect a DC VTVM to the AM output at C-838, the feed-through capacitor with the green wire adjacent to T-808 on the IF amplifier subchassis. Adjust the RECEIVER GAIN control for -1 VDC on the VTVM.

Adjust C-109 for peak indication on the VTVM, and adjust L-110 and T-803 through T-808 to maximize the indication on M-1. Reduce the RECEIVER GAIN control as necessary during the adjustments to maintain -1 VDC at C-838.

Turn the FUNCTION SELECTOR switch to the ATTENUATION MEASUREMENT CW position. Adjust the 608D output attenuator for a CW level of -35 dbm at the VM-3 input, and adjust R-406, the AGC ADJ. control (see figure 6.2) to obtain -1 VDC at C-838. Increase the signal level to -15 dbm; the voltage should not exceed -1.25 VDC. Decrease the signal level to -125 dbm; the voltage should remain greater than 0.75 VDC.

Connect the vertical input of the oscilloscope to the AM output connector. Turn the piston attenuator to 13 db as indicated on the optical readout. Turn C-116 counterclockwise to remove any overload as indicated on the oscilloscope.

Remove the tee from the input of the VM-3 and replace with the 50Ω termination. Set the piston attenuator for 140 db and balance the FM meter with the TUNING capacitor, C-109. Adjust T-102 so that the AM meter balances with one quarter turn of the noise balance control R-105. The adjustment of C-116 should be rechecked as there is some interaction.

Turn the FUNCTION SELECTOR switch to the RECEIVER EXT. MOD. position, and set up the equipment as shown in figure 5.9. With the sweep generator set to

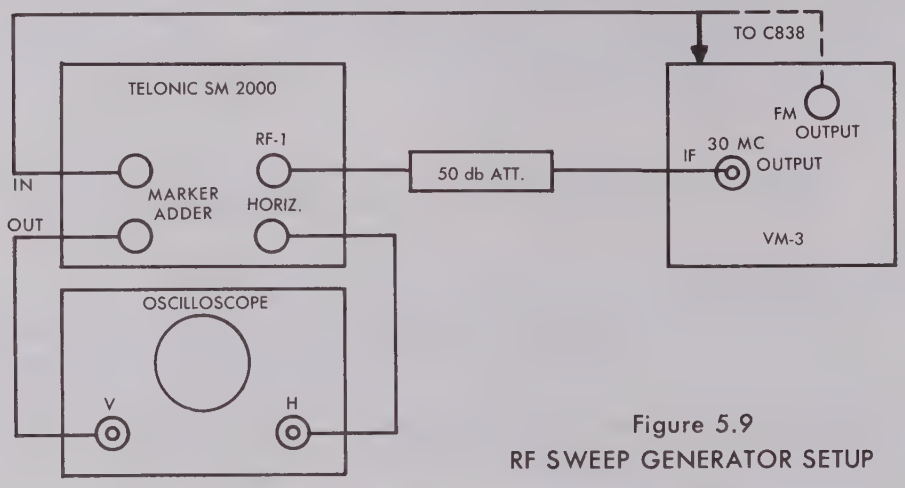


Figure 5.9
RF SWEEP GENERATOR SETUP

sweep around 30 mc, set the VM-3 RECEIVER GAIN control to mid-position and adjust the sweep output attenuator for a peak AM output from the VM-3 at J-13 of 1 volt as indicated on the oscilloscope. See figure 5.10.

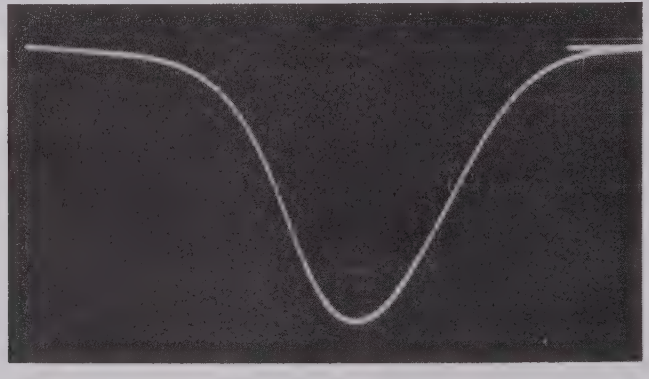


Figure 5.10 IF Amplifier Response (1.0 VPP)

Connect the vertical input of the oscilloscope at the FM output connector, J-14. Remove V-602 from its socket to avoid load on the discriminator during alignment. Adjust T-809 and T-810 for a symmetrical discriminator characteristic as shown in figure 5.11.

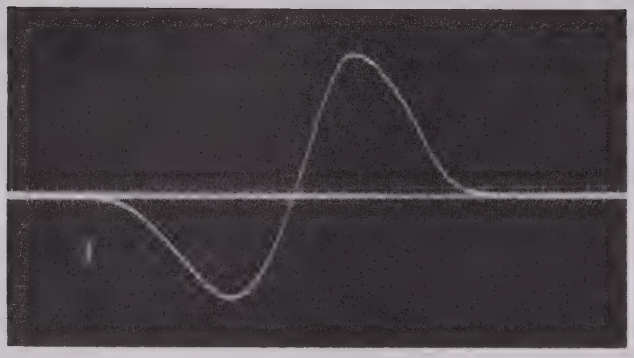


Figure 5.11 30 MC Discriminator Response

Disconnect the 50-db attenuator from the sweep generator and connect the oscilloscope to C-838. Adjust the RECEIVER GAIN control clockwise until a -1 volt DC shift in noise level is indicated on the scope. Reconnect the 50-db attenuator to the sweep generator and the scope vertical input to the FM output. Reduce the RF input with the sweep attenuator. The characteristic S-curve of the discriminator should be preserved until it disappears into the noise. If the curve shows a tendency to lose symmetry at low signal levels, slightly readjust T-809.

Replace V-602. Disconnect the sweep generator from the setup and reconnect the HP-608D and the 20-db attenuator into the type N tee, again terminating the open arm of the tee with 50Ω. Set the 608D output attenuator to 125 db and turn the FUNCTION SELECTOR switch of the VM-3 in the RECEIVER CW position.

Turn the RECEIVER GAIN control fully clockwise. Adjust the TUNING control, C-109, for balance on the FM deviation meter. Adjust the ZERO SIGNAL BALANCE control, R-105, for a minimum DC voltage as indicated on the DC VTVM connector to C-838. Multiply the DC VTVM voltage indication by 1.4 and record the calculated value. Increase the 608D output signal level until an increase in DC voltage is noted on the DC VTVM. The 608D output attenuator setting plus 20 db is the minimum discernible signal in the receiver mode.

Increase the signal generator output until the DC VTVM indicates the recorded calculated output level. The dbm level shown on the 608D output attenuator plus 20 db is the input signal level necessary to increase the VM-3 output 3 db above noise.

5.2.8 AM Modulation

5.2.8.1 Meter Ranges (BROADBAND)

Connect a 30 MC generator, with a calibrated precent modulation meter, to the input of the VM-3 through 40 db of external pads. Connect an external variable oscillator to the EXT. MOD. input to the generator. Set the frequency of this oscillator to the desired modulation frequency. Set the AMPLITUDE MODULATION FREQ. RESP. control to Broadband position. Set the Modulation Selector of the generator to the External position and adjust the Percent Mod. Control to the calibrated 35% indication of the Percent Mod. Meter. Adjust the input level to the VM-3 to be between -50 and -80 dbm.

Set the METER FUNCTION selector of the VM-3 to the CAL. position and depress the DEPRESS FOR ZERO switch and adjust the ADJUST FOR ZERO knob to give a zero indication on the main meter. Next adjust the ADJUST FOR F.S. control for full scale indication on the main meter. Set the METER FUNCTION selector to the 35% AM position and observe the indication on the meter. The indication should be 35% ±5% of full scale. If meter is not within specifications, adjust R726 (See Figure 6.2) for full scale deflection.

Change the METER FUNCTION selector to the 100% AM position and adjust the Percent Mod. control of the generator to the calibrated 80% indication on the Percent Mod. Meter. Next observe the indication on the VM-3 meter. It should indicate 80% ±5% of full scale. If the meter is not within specifications, adjust R725 (see Figure 6.2) for an 80% indication.

5.2.8.2 Meter Ranges (1000 CPS)

Set up the equipment as described in 5.2.8.1 with this exception. Instead of connecting an external variable oscillator to the Ext. Mod. input of the generator, connect the Sine Wave output of the VM-3 to this input. Set AMPLITUDE MODULATION FREQ. RESP. control to 1000 CPS position. Adjust the Percent Modulation Control on the generator to the calibrated 80% indication on the Percent Modulation Meter

Set the METER FUNCTION selector of the VM-3 to the CAL. position and depress the DEPRESS FOR ZERO switch and adjust the ADJUST FOR ZERO knob to give a zero indication on the meter. Next adjust the ADJUST FOR F.S. control for full scale indication on the meter. Set the METER FUNCTION selector to the 100% AM position and observe the indication on the VM-3 meter. It should indicate 80% ±5% of full scale. If the meter is not within specifications, adjust L701 for maximum indication and adjust R708 for an 80% indication (See Figure 6.2).

5.2.8.3 Meter Ranges (400 CPS)

Set up the equipment as described in 5.2.8.1 with this exception. Set the external variable oscillator to 400 CPS and set the AMPLITUDE MODULATION FREQ. RESP. control to the 400 CPS position. Adjust the Percent Mod. control on the generator to the calibrated 80% indication on the Percent Modulation Meter.

Set the METER FUNCTION selector of the VM-3 to the CAL. position and depress the DEPRESS FOR ZERO switch and adjust the ADJUST FOR ZERO knob to give a zero indication on the meter. Next adjust the ADJUST FOR F.S. control for full scale indication on the meter. Set the METER FUNCTION selector to the 100% AM position and observe the indication on the VM-3 meter. It should indicate 80% ±5% of full scale. If the meter is not within specifications, adjust R710 for an 80% indication (See Figure 6.2).

5.2.9 FM Modulation

Connect a 30 MC FM generator through 40 db of external pads to the input of the VM-3. Tune the FM generator to 30 MC with "0" FM introduced.

Turn the FUNCTION SELECTOR of the VM-3 to the FM position. Turn the METER FUNCTION selector to 100 KC FM. Depress the DEPRESS FOR ZERO button and adjust the ADJUST FOR ZERO knob to zero the output meter. Turn the METER FUNCTION selector to the CAL. position and adjust the ADJUST FOR F.S. knob for

a full scale indication on the output meter. Turn the METER FUNCTION selector back to the 100 KC FM position. Also be sure that the AMPLITUDE MODULATION FREQ. RESP. phase selector (red knob) is in the NEG. position.

Introduce 50 KC of FM on the 30 MC input signal and observe the output meter. The indication should be between 35 KC and 65 KC. If meter is not within specification adjust R727 (See Figure 6.2) for proper indication. Turn the METER FUNCTION selector to the 1 MC FM position and introduce 500 KC of FM on the input signal and observe the indication of the output meter. This indication should be between 350 KC and 650 KC. If meter is not within specification adjust R701 (See Figure 6.2) for proper indication. Repeat both of these adjustments as there may be some interaction between R701 and R727.

5.2.10 Receiver Operation

Connect an HP-608D to the input of the VM-3. Through 40 db of external padding connect the 1000 cps square wave output of the VM-3 to the EXT. MOD. input of the HP-608D. Modulate the HP-608D 100% and set the output attenuator to 0 dbm.

Set the FUNCTION SELECTOR switch to RECEIVER EXT. MOD., set the METER FUNCTION selector to RECEIVER OUTPUT, set RECEIVER GAIN control to minimum. Connect an AC VTVM HP Model 400D or equivalent to the video output connector, J-19. Refer to TEST RECORD sheet of VM-3 under test. Note the RMS voltage RECEIVER GAIN until the AC VTVM indicates this voltage. Disconnect the AC VTVM from J-19 and in its place connect a VSWR indicator. Adjust the VSWR indicator gain to indicate zero. Decrease the VM-3 input level by a known 10 db and increase the VSWR gain by 10 db. The VSWR indicator should return to approximately zero. Decrease the input to the VM-3 again by 10 db and increase the gain of the VSWR indicator by 10 db and again the indication should be approximately zero. Decrease the input of the VM-3 by 15 db and increase the gain of the VSWR indicator by 10 db and the indication should read approximately 5 db. All readings should be within 1 db.

5.2.11 Insertion Loss

Set up the equipment as in figure 3.2 using a 1 gc signal frequency. Use setup procedure as set down in Paragraph 3.4.1.2 of Section III.

Turn the AFF selector off and tune the L.O. to obtain an indication near null on the FM meter. Turn the AFF selector to the SLOW position. Observe the FM output on an oscilloscope and note the peak to peak FM amplitude. Turn the AFF selector to SLOW AND FAST, increase the FAST gain until the signal begins to "motorboat". Decrease the gain until the "motorboating" just stops. There should be approximately a 20 to 1 reduction in the amplitude of the beat signal.

Set an input level to the mixer of -35 dbm and null the AMPLITUDE BALANCE with the standard attenuator in the VM-3. Set the meter SENSITIVITY control to about 2 o'clock. Vary the STANDARD ATTENUATOR until the AMPLITUDE BALANCE meter indicates on the last division to the left of null, note the reading of the optical readout. Now vary the STANDARD ATTENUATOR until the meter indicates on the last division to the right of null. Subtract the former from the latter to obtain meter sensitivity. Repeat these procedures at levels of -90 dbm and -115 dbm. It will be necessary to increase the SENSITIVITY setting as you descend in input level.

Return to an input level of -35 dbm and null the AMPLITUDE MODULATION meter. Note the indication on the optical readout. Turn the AFF selector to OFF. At the point indicated on Figure 3.2 insert a known 20 db attenuator. Vary the STANDARD ATTENUATOR until the meter indicates near null, turn the AFF selector to SLOW AND FAST and balance the meter, noting the indication of the optical readout. The difference between the former and the latter should be the value of the inserted attenuator ± .02 db.

Repeat the above procedure for checking known values of 40 db, 60 db, 80 db, and 100 db attenuators, with the following exceptions: The input level for the 60 db and 80 db measurements should be -25 dbm and the input level for the 100 db measurement should be -15 dbm.

5.2.12 Output Jacks

Turn on the VM-3 and connect a scope vertical input to the square wave output jack, turn the square wave level control maximum clockwise and observe the peak to peak indication on the scope. The square wave should be at lease 65V p-p.

Connect the square wave output to the trigger input of the scope and change the sync selector of the scope to ext. Connect the vertical input of the scope to the sine wave output of the VM-3, turn the sine wave level control maximum CW, and observe the peak to peak indication of the scope. It should be at least 30V p-p. Vary the FINE PHASE ADJUST of the VM-3 and observe the sine wave phase shift with respect to the square wave. It should shift at least ±45°.

SECTION VI

PARTS LIST

6.1 Introduction

Designation symbols have been assigned to identify all electric and electronic components comprising the Attenuator and Signal Calibrator, Model VM-3. These symbols are marked on the equipment adjacent to the identified component; they also appear in the schematic diagram in the back of this book and in the parts list, Table 6.1.

6.2 Parts List

Table 6.1 provides a complete listing of all components. The first column lists the symbols in alphanumerical order, the second column lists the manufacturer's code letter which is identified in Table 6.2. The third column gives a description of the component, and the fourth column lists the Weinschel part number.

Figures 5.1 and 5.2 and 6.1 thru 6.5 can be used to identify and locate the various components.

TABLE 6.1
ELECTRICAL PARTS LIST
FOR MODEL VM-3
SERIAL NOS. 19 AND ABOVE

Symbol	*Mfr. Code	Description	Weinschel Part No.
C-101	P	Capacitor, Feedthrough, 1500 pf	37-12-1500
C-102		Capacitor, Standoff, 1000 pf	
C-103		Same as C-101	
C-104	W E	Capacitor, Variable, 3-25 pf, Hammarlund APC-25-B Modified	
C-105	P	Capacitor, Ceramic Disc, .002 µfd	
C-106		Same as C-101	
C-107		Same as C-102	
C-108		Same as C-101	
C-109		Same as C-101	
C-110		Same as C-102	
C-111		Same as C-101	
C-112		Same as C-105	
C-113	P	Capacitor, Ceramic Tubular, 15 pf	37-8-15
C-114		Same as C-101	
C-115		Same as C-101	
C-116	BB	Capacitor, Piston Variable, 0.8 - 10 pf	36-12
C-117		Same as C-105	
C-118		Same as C-105	
C-119		Capacitor, Standoff, 1000 pf	
C-120		Same as C-119	
C-121		Same as C-101	
C-122		Same as C-105	
C-123		Same as C-101	

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
C-124		Same as C-105	
C-125		Same as C-105	
C-201	P	Capacitor, Ceramic Tubular, 4.7 pf	37-8-4R7
C-202		Same as C-101	
C-203	E	Capacitor Silver Mica, 300 pf, 500V	34-6-300
C-204		Same as C-101	
C-205	P	Capacitor, Ceramic Tubular, 6.8 pf	37-8-6R8
C-206		Not Used	
C-207	P	Capacitor, Ceramic Tubular, 8.2 pf	27-8-8R2
C-208	P	Capacitor, Ceramic Tubular, 3.3 pf	37-8-3R3
C-209		Same as C-207	
C-210	P	Capacitor, Ceramic Disc, .01 μf	37-2-R001
C-211		Same as C-210	
C-212		Same as C-210	
C-213		Same as C-210	
C-214	P	Capacitor, Feedthrough, 1000 pf	37-12-1000
C-215		Same as C-101	
C-216		Same as C-214	
C-217		Same as C-101	
C-218		Same as C-210	
C-219		Same as C-210	
C-220		Same as C-101	
C-221	P	Capacitor, Standoff, 1000 pf	37-22-R001
C-222		Same as C-221	

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
C-301	J	Capacitor, Polystyrene, 8200 pf, 500V, 5%	39-1-8200
C-302	J	Capacitor, Polystyrene, 560 pf, 500V, 5%	39-1-560
C-303	E	Capacitor, Trimmer, 9-180 pf	36-16
C-304	LL	Capacitor, Electrolytic, 20 µfd, 15V	31-41-20
C-305	LL	Capacitor, Met. Paper, 1.0 µf, 200V	33-6-1
C-306	LL	Capacitor, Molded Paper, .01 µf, 400V	38-4-R01
C-307		Same as C-305	
C-308	LL	Capacitor, Electrolytic, 80/80/60 µf, 250V	32-40
C-309		Same as C-306	
C-310	LL	Capacitor, Molded Paper, .022 µf, 400V	38-4-R022
C-311		Same as C-304	31-41-20
C-312		Same as C-310	
C-313	LL	Capacitor, Polystyrene, 39 pf, 500V, 5%	39-1-39
C-314	LL	Capacitor, Molded Paper, 0.1 µf, 400V	38-4-R1
C-315	DD	Capacitor, Electrolytic, 1500 µf, 50V	32-5
C-316	K	Capacitor, Electrolytic, 250 µf, 50V	31-19
C-317	P	Capacitor, Ceramic Disc, .001 µf, 1 KV	37-2-R001
C-318	E	Capacitor, Mica, 2000 pf, 500V, 5%	34-2-2000
C-401	LL	Capacitor, Electrolytic, 40/40/30/20 µf, 250V	32-43
C-402	LL	Capacitor, Met. Paper, 2 µf, 200V	33-6-2
C-403	A	Capacitor, Electrolytic, 20 µf, 30V NP	31-42
C-404	LL	Capacitor, Electrolytic, 20 µf, 50V	31-38-20
C-405		Same as C-315	
C-406		Same as C-314	

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
C-501	LL	Capacitor, Electrolytic, 50 µf, 25V	31-37-50
C-502		Same as C-308	
C-503		Same as C-404	
C-504		Same as C-314	
C-505		Same as C-314	
C-506	T	Capacitor, Electrolytic, 500 µf, 15V, NP	32-38
C-507		Same as C-403	
C-508		Same as C-210	
C-509		Same as C-210	
C-601		Same as C-306	
C-602		Same as C-501	
C-603		Same as C-306	
C-604		Same as C-304	
C-605		Same as C-314	
C-606		Not Used	
C-607		Same as C-306	
C-608		Same as C-317	
C-609		Same as C-317	
C-610		Same as C-314	
C-611		Same as C-306	
C-612		Same as C-403	
C-613		Same as C-306	
C-614		Same as C-306	
C-615	LL	Capacitor, Molded Paper, 0.22 µf, Nom., 400V (Value Selected at Test)	38-4-R22

Symbol	*Mfr. Code	Description	Weinschel Part No.
C-616		Same as C-501	
C-617	Q	Capacitor, Plastic, .02 µf, 3 KV	33-18-R02
C-618	HH	Capacitor, Plastic, 1.0 µf, 3 KV	35-35
C-619	P	Capacitor, Ceramic Disc, .01 µf, 3 KV	37-19-R01
C-620		Same as C-305	
C-621		Same as C-305	
C-622	LL	Capacitor, Electrolytic, 2.0 µf, 50V	31-38-2
C-623		Not Used	
C-624		Not Used	
C-625		Not Used	
C-626		Not Used	
C-627		Not Used	
C-628		Not Used	
C-629		Not Used	
C-630		Not Used	
C-631		Not Used	
C-632		Not Used	
C-633		Not Used	
C-634		Not Used	
C-635		Not Used	
C-636		Not Used	
C-637	V	Capacitor, Metalized Mylar, 2 µf, 200V	33-35-2
C-638		Not Used	
C-639		Not Used	
C-640	LL	Capacitor, Molded Paper, .5 µf, 400V	33-2-R5

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
C-701	J	Capacitor, Polystyrene, 1000 pf, 500V, 5%	39-1-1000
C-702	J	Capacitor, Polystyrene, 120 pf, 500V, 5%	39-1-120
C-703		Same as C-701	
C-704	J	Capacitor, Polystyrene, 800 pf, 500V, 5%	39-1-800
C-705	E	Capacitor, Silver Mica, .027 µf, 300V, 5%	34-2-27000
C-706	LL	Capacitor, Molded Paper, .1 µf, Nom., 400V (Value Selected at Test)	38-4-R1
C-707	J	Capacitor, Polystyrene, 47 pf, 500V, 5%	39-1-47
C-708	LL	Capacitor, Molded Paper, .047 µf, 400V	38-4-R047
C-709		Same as C-314	
C-710	LL	Capacitor, Electrolytic, 10 µf, 25V	31-37-10
C-711	LL	Capacitor, Molded Paper, 0.22 µf, 400V	38-4-R22
C-712		Same as C-711	
C-713	P	Capacitor, Ceramic Disc, .005 µf	37-2-R005
C-714		Same as C-713	
C-715		Same as C-306	
C-716		Same as C-314	
C-717		Same as C-314	
C-718	LL	Capacitor, Molded Paper, 0.1 mfd, 400V	38-4-R1
C-801		Same as C-210	
C-802		Same as C-210	
C-803	P	Capacitor, Ceramic Disc, .001 mfd, 600V	37-2-R001
C-804		Same as C-803	
C-805		Same as C-317	
C-806		Same as C-210	

Symbol	*Mfr. Code	Description	Weinschel Part No.
C-807		Same as C-210	
C-808	P	Capacitor, Ceramic Tubular, 20 pf	37-0-20
C-809		Same as C-210	
C-810		Same as C-210	
C-811	LL	Capacitor, metalized paper, 0.1 µf, 200 V	33-6-R1
C-812		Same as C-101	
C-813		Same as C-210	
C-814		Same as C-808	
C-815		Same as C-210	
C-816		Same as C-317	
C-817	P	Capacitor, Ceramic Disc, .02 µfd	37-2-R02
C-818		Same as C-210	
C-819		Same as C-808	
C-820		Same as C-210	
C-821		Same as C-317	
C-822		Same as C-210	
C-823		Same as C-210	
C-824		Same as C-808	
C-825		Same as C-210	
C-826		Same as C-317	
C-827	LL	Capacitor, Met. Paper, .1 µf, 200V	33-6-R1
C-828		Same as C-210	
C-829		Same as C-214	
C-830		Same as C-808	
C-831		Same as C-210	
C-832		Same as C-317	

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
C-833		Same as C-210	
C-834		Same as C-210	
C-835		Same as C-210	
C-836		Same as C-317	
C-837		Same as C-210	
C-838	B	Capacitor, Feedthrough, 100 pf	37-17-100
C-839	J	Capacitor, Polystyrene, 100 pf, 500V	39-1-100
C-840		Same as C-210	
C-841	P	Capacitor, Ceramic Tubular, 5 pf	37-8-5
C-842		Same as C-210	
C-843		Same as C-811	
C-844		Same as C-101	
C-845	B	Capacitor, Feedthrough, 10 pf	37-17-10
C-846	P	Capacitor, Ceramic Tubular, 10 pf	37-8-10
C-847		Same as C-210	
C-848	P	Capacitor, Ceramic Tubular, 18 pf	37-8-18
C-849	B	Capacitor, Standoff, 10 pf	37-16-10
C-850		Same as C-846	
C-851		Same as C-210	
C-852		Same as C-849	
C-853	J	Capacitor, Polystyrene, 330 pf, 500V	39-1-330
C-854		Same as C-849	
C-855		Same as C-101	
C-856		Same as C-317	
C-857		Same as C-827	
C-858		Same as C-317	

Symbol	*Mfr. Code	Description	Weinschel Part No.
C-859		Same as C-317	
C-860		Same as C-317	
C-861		Same as C-317	
C-862		Same as C-317	
C-863		Same as C-101	
C-864	P	Capacitor, Ceramic Disc, .01 µfd	37-2-R01
C-865		Same as C-210	
C-866	LL	Capacitor, Poly-film, .47 µf, 200V	39-2-R47
C-867		Same as C-101	
C-868		Same as C-210	
C-869		Same as C-317	
C-870		Same as C-839	
C-871		Same as C-839	
C-872		Same as C-210	
C-873		Same as C-210	
C-874		Same as C-827	
C-875		Same as C-702	
C-876		Same as C-839	
C-877		Same as C-101	
C-878		Same as C-811	
C-879		Same as C-811	
C-901	LL	Capacitor, Electrolytic, 200 µf, 250V	32-41
C-902	DD	Capacitor, Electrolytic, 1500 µf, 50V	32-5
C-903	LL	Capacitor, Electrolytic, 500 µf, 50V	32-42
C-904	LL	Capacitor, Molded Paper, 0.1 µf, 200V	38-2-R1
C-905	LL	Capacitor, Electrolytic, 20 µf, 50V	31-38-20
C-906		Same as C-902	

Symbol	*Mfr. Code	Description	Weinschel Part No.
C-907	K	Capacitor, Electrolytic, 30 µf, 250V	31-24
C-908	LL	Capacitor, Electrolytic, 25 µf, 25V	31-27-25
C-909	LL	Capacitor, Electrolytic, 25 µf, 150V	31-63
CR-101	00	Diode, 1N270	12-45
CR-102		Same as CR-101	
CR-201		Same as CR-101	
CR-202	PP	Diode, 1N3009A	12-61
CR-601	S	Diode, 1N914A	12-51
CR-602		Same as CR-601	
CR-603	00	Diode, 1N463	12-37
CR-604		Same as CR-603	
CR-701		Same as CR-601	
CR-702		Same as CR-601	
CR-703	00	Diode, 1N2071A	12-41
CR-801		Same as CR-101	
CR-802	00	Diode, 1N34A	12-1
CR-803		Same as CR-802	
CR-804		Same as CR-101	
CR-901	KK	Diode, F8	12-53
CR-902		Same as CR-901	
CR-903		Diode, 1N4383	12-110
CR-904		Diode, 1N4383	12-110

*See Table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
CR-905	FF	Diode, 1N3209	12-54
CR-906		Same as CR-905	
CR-907	FF	Diode, 1N3030B	12-55
CR-908	AA	Diode, 1N751A	12-50
CR-909		Same as CR-908	
F-901	CC	Fuse, 3 Amp	52-1-3
F-902	CC	Fuse, 0.3 Amp	52-1-.3
F-903	CC	Fuse, 3.2 Amp Slow Blow	52-1-3.2 SB
J-1	G	Connector, Flush Motor Base, 3 Contact	A62-38
J-2	C	Connector, Female, 5 pin	62-74
J-3		Same as J-2	
J-4	N	Connector, Printed Ckt. Type, 19 Contact	62-66
J-5		Same as J-4	
J-6		Same as J-4	
J-7	N	Connector, Printed Ckt. Type, 35 Contact	62-68
J-8	N	Connector, Plug with locknut	62-71
J-9	C	Connector, Female, 9 pin	62-76
J-10	I	Connector, 2 Contact, 3102A-22-11P	62-36
J-11	D	Connector, BNC Jack, Crimp Type	63-54
J-12		Same as J-11	
J-13		Same as J-11	
J-14		Same as J-11	
J-15	Z	Connector, BNC, Chassis Mount	63-16
J-16	Z	Connector, BNC, Right Angle, Chassis Mount	63-52

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
J-17	U	Connector, TNC, Chassis Mount	63-50
J-18		Same as J-17	
J-19	Z	Connector, BNC, Chassis Mount	63-14
J-20	W/E	Connector, Input Jack Assembly	A118-39
J-21		Same as J-2	
K-601	II	Relay, D.P.D.T, 115 VAC	47-9
L-101	RR	Choke, R.F., 27 µh	41-11
L-102		Same as L-101	
L-103		Same as L-101	
L-104		Same as L-101	
L-105		Same as L-101	
L-106		Same as L-101	
L-107		Same as L-101	
L-108		Same as L-101	
L-109	RR	Choke, R.F., 4.7 µh, Stanwyck #DINK-4.7	41-19
L-110		30 Mc Pre-amp Output Coil	
L-111		Same as L-109	
L-112		Same as L-101	
L-201		Same as L-101	
L-202	W/E	30 Mc Oscillator Coil	B118-174
L-203		Same as L-101	

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
L-204		Same as L-202	
L-205		Not Used	
L-206		Same as L-101	
L-207		Same as L-101	
L-208		Same as L-101	
L-209		Same as L-101	
L-210		Same as L-101	
L-211		Same as L-101	
L-212		Same as L-101	
L-301		Same as L-101	
L-302		Same as L-101	
L-701	H	Adjustoroid, 0.94H	40-71
L-801		Same as L-101	
L-802		Same as L-101	
L-803		Same as L-101	
L-804		Same as L-101	
L-805		Same as L-101	
L-806		Same as L-101	
L-807		Same as L-101	
L-808		Same as L-101	
L-809		Same as L-101	
L-810		Same as L-101	

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
L-811		Same as L-101	
L-812		Same as L-101	
L-813		Same as L-101	
L-814		Same as L-101	
L-815		Same as L-101	
L-816		Same as L-101	
L-817		Same as L-101	
L-818		Same as L-101	
L-819		Same as L-109	
L-820		Same as L-101	
L-821		Same as L-101	
L-822		Same as L-101	
L-823		Same as L-101	
L-824		Same as L-101	
L-825		Same as L-101	
L-826		Same as L-101	
L-827		Same as L-101	
L-828		Same as L-101	
L-829		Same as L-101	
L-830		Same as L-101	
L-832		Same as L-101	
L-901	MM	Choke, Filter, 4h, 60 ohm	40-103
L-902	MM	Choke, Filter, 0.32h, 10 ohm	40-104
L-903	MM	Choke, Filter, .025h, 0.425 ohm	40-102

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part. No.
M-1	W/E	Meter, 0-200 μa	A83-3
M-2	Y	Meter, Null Indicator, 100-0-100 us	16-32
M-3		Same as M-2	
P-1	SS	3 Conductor Power Cord with Male and Female Connectors	B68-3
P-2a	C	Connector, Male, 5 pin, with Hood and Clamp	62-75
P-2b		Same as P-2a	
P-3		Same as P-2a	
P-4		Not Used	
P-5		Not Used	
P-6		Not Used	
P-7		Not Used	
P-8	N	Connector, Receptacle, with Cover and Activating Screw	62-72
P-9	C	Connector, Male, 9 pin, with Hood and Clamp	62-77
P-10	C	Connector, Cable Type, 2 Contact, 90°, 3108A-22-11S AN 3057-12, AN 3111-6, AN 3420-12	62-37
P-11		Not Used	
P-12		Not Used	
P-13		Not Used	
P-14		Not Used	
P-15	Z	Connector, BNC, Cable	63-48
P-16		Not Used	
P-17	Z	Connector, TNC, Cable	63-47
P-18	X	Connector, TNC, Cable, 90°	63-53
P-19		Not Used	
P-20		Not Used	
P-21		Same as P-2a	

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
PL-1	S	Lamp, 6-8 volts, #47	50-1
PL-2	S	Lamp, 4.75 volts, 0.5a, PR-12	50-17
PL-3	QQ	Lamp, 120 volts, 3W	50-2
PL-4	S	Lamp, Neon, NE-7	50-15
Q-301	PP	Transistor, 2N697	12-56
Q-401	PP	Transistor, 2N1374	12-57
Q-901		Same as Q-401	
Q-902		Same as Q-301	
Q-903	FF	Transistor, 2N1544	12-59
Q-904		Same as Q-401	
Q-905	FF	Transistor, 2N1542	12-58
R-101	B	Resistor, Comp., 1K ohm, 5%, 1/2W	25-8-1000
R-102		Same as R-101	
R-103	B	Resistor, Comp., 39 ohm, 5%, 1/2W	25-8-39
R-104	B	Resistor, Comp., 3.3K, 10%, 1/2W	25-1-3300
R-105	GG	Resistor, Variable, 500K ohms, 2W	20-19
R-106		Not Used	
R-107	GG	Resistor, Comp., 27K, 10%, 1/2W	25-1-27K
R-108	B	Resistor, Comp., 47 ohm, 5%, 1/2W	25-8-47
R-109		Same as R-104	
R-110	B	Resistor, Comp., 68 ohm, 5%, 1/2W	25-8-68
R-111	B	Resistor, Comp., 2.7K, 10%, 2W	25-3-2700

*See Table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
R-201	B	Resistor, Comp., 560 ohm, 5%, 1/2W	25-8-560
R-202	B	Resistor, Comp., 27K ohm, 5%, 1/2W	25-8-27K
R-203	B	Resistor, Comp., 68K ohm, 5%, 1/2W	25-8-68K
R-204	B	Resistor, Comp., 47K ohm, 10%, 1W	25-2-47K
R-205	B	Resistor, Comp., 100K ohm, 5%, 1/2W	25-8-100K
R-206	B	Resistor, Comp., 470 ohm, 5%, 1/2W	25-8-470
R-207	B	Resistor, Comp., 15K ohm, 5%, 1/2W	25-8-15K
R-208	GG	Resistor, Variable, 50K ohm, 2W	20-14
R-209	B	Resistor, Comp., 3.3K ohm, 5%, 1/2W	25-8-3300
R-210	B	Resistor, Comp., 820 ohm, 5%, 1/2W	25-8-820
R-301	O	Resistor, Film, 68.1K ohm, 1%, 1/2W	25-4-68R1K
R-302		Same as R-301	
R-303	J	Resistor, Variable, 500 ohm, 1/2W	20-126
R-304		Same as R-209	
R-305	B	Resistor, Comp., 150K ohm, 5%, 1/2W	25-8-150K
R-306	B	Resistor, Comp., 1 Meg ohm, 10%, 1/2W	25-1-1M
R-307	B	Resistor, Comp., 1 Meg ohm, 5%, 1/2W	25-8-1M
R-308	B	Resistor, Comp., 5.6K ohm, 5%, 1/2W	25-8-5600
R-309	B	Resistor, Comp., 150 ohm, 5%, 1/2W	25-8-150
R-310	B	Resistor, Comp., 15K ohm, 10%, 1/2W	25-1-15K
R-311	B	Resistor, Variable, 25K ohm 2W	20-117
R-312	B	Resistor, Comp., 2.2K ohm, 5%, 1/2W	25-8-2200
R-313	B	Resistor, Comp., 3.3K ohm, 5%, 1W	25-8-3300
R-314	B	Resistor, Comp., 22K ohm 5%, 1/2W	25-8-22K

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
R-315	B	Resistor, Comp., 220K ohm, 5%, 1/2W	25-8-220K
R-316		Same as R-308	
R-317	B	Resistor, Comp., 68K ohm, 1/2W, 10%	25-1-68K
R-318	B	Resistor, Comp., 2.7K, 10%, 1/2W	25-1-2700
R-319	B	Resistor, Comp., 470K ohm, 10%, 1/2W	25-1-470K
R-320	B	Resistor, Comp., 47K ohm, 5%, 1/2W	25-8-47K
R-321	B	Resistor, Comp., 18K ohm, 5%, 1/2W	25-8-18K
R-322		Same as R-320	
R-323	B	Resistor, Comp., 120K ohm, 5%, 1/2W	25-8-120K
R-324	B	Resistor, Comp., 2.2 Meg ohm, 5%, 1/2W	25-8-2R2M
R-325	B	Resistor, Comp., 10 Meg ohm, 5%, 1/2W	25-8-10M
R-326	B	Resistor, Variable, 5K ohm, 2W (Dual Concentric with R-420)	20-119
R-327	B	Resistor, Comp., 470 ohm, 10%, 1W	25-2-470
R-328	B	Resistor, Comp., 2.7K ohm, 5%, 1/2W	25-8-2700
R-329	B	Resistor, Comp., 6.8K ohm, 5%, 1/2W	25-8-6800
R-330	B	Resistor, Comp., 390 ohm, 5%, 2W	25-8-390
R-331	M	Resistor, Wirewound, 5K ohm, 5%, 10W	26-7-5K
R-332	B	Resistor, Comp., 2.2K ohm, 5%, 1/2W	25-8-2200
R-333	B	Resistor, Comp., 180 ohm, 10%, 1/2W	25-1-180
R-334	B	Resistor, Comp., 820 ohm, 10%, 1/2W	25-1-820
R-335	B	Resistor, Comp., 1K ohm, 10%, 1/2W	25-1-1000
R-336	B	Resistor, Comp., 220K ohm, 5%, 1/2W	25-8-220K
R-401	B	Resistor, Comp., 1.5K ohm, 10%, 1/2W	25-1-1500
R-402		Same as R-209	
R-403		Same as R-305	

Symbol	*Mfr. Code	Description	Weinschel Part No.
R-404	B	Resistor, Comp., 330K ohm, 5%, 1/2W	25-8-330K
R-405		Same as R-312	
R-406	J	Resistor, Variable, 1.5K ohm, 1/2W	20-127
R-407	GG	Resistor, Variable, 1K ohm, 2W	20-11
R-408	B	Resistor, Comp., 200 ohm, 5%, 1/2W	25-8-200
R-409	GG	Resistor, Comp., 6.8K, 5%, 1/2W	25-8-6800
R-410	B	Resistor, Comp., 51 ohm, 5%, 1/2W	25-8-51
R-411	M	Resistor, Wirewound, 10K ohm, 5%, 5W	26-6-10K
R-412		Same as R-209	
R-413	B	Resistor, Comp., 47 ohm, 5%, 1/2W	25-8-47
R-414	B	Resistor, Variable, 1K ohm, 2W Ohmite "B" Taper	20-99
R-415	B	Resistor, Comp., 820 ohm, 5%, 1W	25-9-820
R-416	GG	Resistor, Comp., 330K, 5%, 1/2W	25-8-330K
R-417		Same as R-319	
R-418		Same as R-314	
R-419	B	Resistor, Comp., 1.2K ohm, 5%, 1/2W	25-8-1200
R-420	B	Resistor, Variable, 100K ohm, 2W (Dual Concentric with R-326)	20-119
R-421	B	Resistor, Comp., 1.5K ohm, 10%, 2W	25-3-1500
R-501	B	Resistor, Comp., 1 Meg ohm, 5%, 1/2W	25-8-1M
R-502	B	Resistor, Comp., 330 ohm, 10%, 1/2W	25-1-330
R-503	B	Resistor, Comp., 39K ohm, 5%, 1W	25-9-39K
R-504	B	Resistor, Comp., 120K ohm, 5%, 1/2W	25-8-120K

*See Table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
R-505		Same as R-312	
R-506	B	Resistor, Comp., 33K ohm, 5%, 1/2W	25-8-33K
R-507	B	Resistor, Comp., 470K ohm, 10%, 1/2W	25-1-470K
R-508	B	Resistor, Variable, 10K ohm, 2W (Dual Concentric with R-510)	20-118
R-509	GG	Resistor, Variable, 10K ohm, 2W	20-30
R-510	B	Resistor, Variable, 500K ohm, 2W (Dual Concentric with R-508)	20-118
R-511	B	Resistor, Comp., 470 ohm, 5%, 1/2W	25-8-470
R-512		Same as R-320	
R-513		Same as R-506	
R-514		Same as R-312	
R-515	B	Resistor, Comp., 82K ohm, 5%, 1/2W	25-8-82K
R-516		Same as R-312	
R-517	B	Resistor, Comp., 200 ohm, 5%, 1/2W	25-8-200
R-518	B	Resistor, Comp., 100K ohm, 10%, 1/2W	25-1-100K
R-519		Same as R-320	
R-520	B	Resistor, Comp., 10K ohm, 5%, 1/2W	25-8-10K
R-601		Same as R-319	
R-602	B	Resistor, Comp., 1.5K ohm, 10%, 1/2W	25-1-1500
R-603	B	Resistor, Comp., 100K ohm, 10%, 1/2W	25-1-100K
R-604		Same as R-101	
R-605	B	Resistor, Comp., 470K ohm, 10%, 1/2W	25-1-470K
R-606	B	Resistor, Comp., 22K ohm, 5%, 1/2W	25-8-22K
R-607	B	Resistor, Comp., 680 ohm, 5%, 1/2W	25-8-680

Symbol	*Mfr. Code	Description	Weinschel Part No.
R-608	B	Resistor, Comp., 330 ohm, 10%, 1/2W	25-1-330
R-609	B	Resistor, Comp., 15K ohm, 5%, 1/2W	25-8-15K
R-610	B	Resistor, Comp., 150K ohm, 5%, 1/2W	25-8-150K
R-611		Same as R-203	
R-612	B	Resistor, Comp., 7.5K ohm, 5%, 1W	25-9-7500
R-613	B	Resistor, Comp., 8.2K ohm, 5%, 1W	25-9-8200
R-614		Same as R-205	
R-615		Same as R-205	
R-616		Same as R-307	
R-617		Same as R-307	
R-618	B	Resistor, Comp., 470 ohm, 5%, 1W	25-9-470
R-619	B	Resistor, Comp., 220K, 1/2W, 10%	25-1-220K
R-620		Same as R-619	
R-621		Same as R-101	
R-622	B	Resistor, Comp., 15K ohm, 5%, 1/2W	25-8-15K
R-623	J	Resistor, Variable, 500 ohm, 1/2W	20-126
R-624		Same as R-101	
R-625	B	Resistor, Comp., 8.2K ohm, 5%, 1/2W	25-8-8200
R-626	GG	Resistor, Variable, 50K ohm, 2W	20-1
R-627		Not Used	
R-628		Same as R-625	
R-629	GG	Resistor, Variable, 250K ohm, 2W	20-45
R-630		Not Used	
R-631	B	Resistor, Comp., 300 ohm, 5%, 1/2W	25-8-300
R-632	B	Resistor, Comp., 39K ohm, 10%, 1/2W	25-1-39K
R-633		Same as R-603	
R-634	B	Resistor, Comp., 470K ohm, 5%, 1/2W	25-8-470K

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
R-635		Same as R-634	
R-636	B	Resistor, Comp., 7.5K ohm, 5%, 1W	25-9-7500
R-637	B	Resistor, Comp., 100K, 1/2W, 10%	25-1-100K
R-638	B	Resistor, Comp., 47K ohm, 5%, 1W	25-9-47K
R-639	GG	Resistor, Variable, 100K ohm, 2W	20-18
R-640		Same as R-205	
R-641		Same as R-205	
R-642		Same as R-619	
R-643		Same as R-307	
R-644		Same as R-307	
R-645		Same as R-603	
R-646		Same as R-603	
R-701	J	Resistor, Variable, 25K ohm, 1/2W	20-122
R-702	B	Resistor, Comp., 43K ohm, 5%, 1/2W	25-8-43K
R-703	O	Resistor, Film, 500K ohm, 1%, 1/2W	25-4-500K
R-704		Same as R-305	
R-705		Same as R-603	
R-706	B	Resistor, Comp., 2.7K ohm, 5%, 1/2W	25-8-2700
R-707	B	Resistor, Comp., 100 K ohm, 5%, 1/2W	25-8-100K
R-708	J	Resistor, Variable, 500K ohm, 1/2W	20-141
R-709	B	Resistor, Comp., 220K ohm, 10%, 1/2W	25-1-220K
R-710	J	Resistor, Variable, 50K ohm, 1/2W	20-121
R-711		Same as R-603	
R-712	B	Resistor, Comp., 220K ohm, 5%, 1/2W	25-8-220K
R-713	O	Resistor, Film, 600 ohm, 1%, 1/2W	25-4-600
R-714	O	Resistor, Film, 1.2K ohm, 1%, 1/2W	25-4-1200

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
R-715		Same as R-603	
R-716	B	Resistor, Comp., 82K ohm, 5%, 1/2W	25-8-82K
R-717		Same as R-319	
R-718	B	Resistor, Comp., 680 ohm, 10%, 1/2W	25-1-680
R-719		Same as R-603	
R-720	B	Resistor, Comp., 3.3K ohm, 5%, 1W	25-9-3300
R-721	B	Resistor, Comp., 22K ohm, 5%, 1/2W	25-8-22K
R-722	B	Resistor, Comp., 33K ohm, 10%, 1/2W	25-1-33K
R-723		Same as R-722	
R-724	B	Resistor, Comp., 82K ohm, 5%, 1/2W	25-8-82K
R-725	J	Resistor, Variable, 25K ohm, 1/2W	20-122
R-726		Same as R-725	
R-727	J	Resistor, Variable, 50K ohm, 1/2W	20-121
R-728		Same as R-205	
R-729	B	Resistor, Comp., 4.7 Meg ohm, 5%, 1/2W	25-8-4R7M
R-730		Same as R-729	
R-731	B	Resistor, Comp., 200K ohm, 5%, 1/2W	25-8-200K
R-732		Same as R-731	
R-733		Same as R-729	
R-734		Same as R-319	
R-735		Same as R-307	
R-736	B	Resistor, Comp., 1.5K ohm, 5%, 1/2W	25-8-1500
R-737	J	Resistor, Variable, 3K ohm, 1/2W	20-124
R-738	B	Resistor, Comp., 3K ohm, 5%, 1/2W	25-8-3000
R-739	M	Resistor, Wirewound, 60.7 ohm, 1%, 1/2W	26-3-60R7
R-740	GG	Resistor, Variable, 1K ohm, 2W	20-11

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
R-741		Same as R-736	
R-742		Same as R-319	
R-801	B	Resistor, Comp., 100K, 1/2W, 5%	25-8-100K
R-802	B	Resistor, Comp., 220 ohm, 1/2W, 5%	25-8-220
R-803	B	Resistor, Comp., 1.8K, 1/2W, 5%	25-8-1800
R-804		Not Used	
R-805		Same as R-409	
R-806	0	Resistor, Film, 1210 ohm, 1%, 0.1W	25-16-1210
R-807	B	Resistor, Comp., 15 ohm, 5%, 1/2W	25-8-15
R-808		Same as R-320	
R-809		Same as R-806	
R-810		Same as R-807	
R-811		Same as R-409	
R-812		Not Used	
R-813		Same as R-806	
R-814		Same as R-807	
R-815		Same as R-409	
R-816		Same as R-320	
R-817		Same as R-806	
R-818	B	Resistor, Comp., 160 ohm, 5%, 1/2W	25-8-160
R-819		Same as R-101	
R-820		Same as R-320	
R-821		Same as R-806	
R-822		Same as R-818	

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
R-823		Same as R-101	
R-824		Same as R-409	
R-825		Same as R-409	
R-826		Same as R-603	
R-827		Same as R-320	
R-828		Same as R-209	
R-829		Same as R-336	
R-830		Same as R-209	
R-831	B	Resistor, Comp., 150K ohm, 5%, 1/2W	25-8-150K
R-832		Same as R-320	
R-833	B	Resistor, Comp., 1.2K ohm, 5%, 1/2W	25-8-1200
R-834		Same as R-320	
R-835		Same as R-320	
R-836		Same as R-506	
R-837		Same as R-205	
R-838	B	Resistor, Comp., 82K ohm, 5%, 1/2W	25-8-82K
R-839		Same as R-409	
R-840	B	Resistor, Comp., 51 ohm, 5%, 1/2W	25-8-51
R-901	M	Resistor, Wirewound, 20K ohm, 5%, 5W	26-6-20K
R-902	B	Resistor, Comp., 1K ohm, 10%, 1/2W	25-1-1000
R-903		Same as R-902	
R-904	B	Resistor, Comp., 680 ohm, 10%, 1/2W	25-1-680
R-905	GG	Resistor, Comp., 2.2K, 10%, 2W	25-3-2200
R-906	M	Resistor, Wirewound, 50 ohm, 5%, 5W	26-6-50

*See Table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
R-907	B	Resistor, Comp., 10K ohm, 10%, 1/2W	25-1-10K
R-908		Same as R-902	
R-909	B	Resistor, Comp., 300 ohm, 5%, 1/2W	25-8-300
R-910	J	Resistor, Variable, 200 ohm, 1/2W	20-125
R-911	B	Resistor, Comp., 75 ohm, 5%, 1/2W	25-8-75
R-912	B	Resistor, Comp., 47K ohm, 10%, 2W	25-3-47K
R-913	B	Resistor, Comp., 1.2K ohm, Nom., 5%, 1/2W (Value selected at test)	25-8-122K
R-914	M	Resistor, Wirewound, 1 ohm, 1%, 1W	26-67-1
SW-1	L	Switch, Toggle, SPST	55-1
SW-2	W E	Switch, 12 pole - 6 positions for printed circuit	A56-36
SW-3	W	Switch, Push Button, DPST	55-25
SW-4 SW-9	W E	Switch, Dual Concentric for printed circuit 3 pole - 3 position and 4 pole - 2 position	A56-35
SW-5	W E	Switch, 4 pole - 2 position	A56-38
SW-6 SW-8		Same as SW-4 and SW-9	
SW-7	W E	Switch, 8 pole - 8 position for printed circuit	A56-37
SW-10		Same as SW-3	
SW-11	B	Switch, SPST, Mounted on R-508 and R-510	20-118
SW-12	NN	Switch, Lever, 3 PDT, Locking Type Switchcraft #13009	55-26
THY-501	S	Thyrite	27-1

Symbol	*Mfr. Code	Description	Weinschel Part No.
T-101	W/E	30 Mc Input Transformer	
T-102		Same as T-101	
T-201	W/E	30 Mc Source Output Transformer	B118-175
T-501	EE	Transformer, Interstage	40-17
T-601	W/E	Transformer, Interstage	A40-90
T-801		Not Used	
T-802		Not Used	
T-803	W/E	30 Mc Amplifier Interstage Coil	B118-170
T-804		Same as T-803	
T-805		Same as T-803	
T-806		Same as T-803	
T-807		Same as T-803	
T-808	W/E	30 Mc Amplifier Output Coil	B118-171
T-809	W/E	30 Mc Amplifier Limiter Coil	B118-172
T-810	W/E	30 Mc Discriminator Coil	B118-173
V-101	ZZ	Tube, Electron, 6CW4	10-166
V-102	ZZ	Same as V-101	
V-201	ZZ	Tube, Electron, 6EA8	10-162
V-301	ZZ	Tube, Electron, 6EA8	10-162

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
V-302	ZZ	Tube, Electron, 6DR7	10-161
V-303	ZZ	Tube, Electron, 6BK7B	10-160
V-401	ZZ	Tube, Electron, 12AU7A	10-15
V-402	ZZ	Tube, Electron, 6EA8	10-162
V-501	ZZ	Tube, Electron, 6AU8A	10-159
V-502	ZZ	Tube, Electron, 6AR8	10-33
V-601	ZZ	Tube, Electron, 12AT7	10-67
V-602	ZZ	Tube, Electron, 6EA8	10-162
V-603	ZZ	Tube, Electron, 5814A	10-7
V-604	ZZ	Tube, Electron, 6EA8	10-162
V-605	ZZ	Tube, Electron, 5687	10-117
V-701	ZZ	Tube, Electron, 6EA8	10-162
V-702	ZZ	Tube, Electron, 5687	10-117
V-801	ZZ	Tube, Electron, 6922	10-165
V-802	ZZ	Tube, Electron, 6EH7	10-163
V-803	ZZ	Tube, Electron, 6EH7	10-163
V-804	ZZ	Tube, Electron, 6EH7	10-163
V-805	ZZ	Tube, Electron, 6EJ7	10-164
V-806	ZZ	Tube, Electron, 6EJ7	10-164
V-807	ZZ	Tube, Electron, 6AU6A	10-2
V-808	ZZ	Tube, Electron, 6AU6A	10-2
V-901	ZZ	Tube, Electron, 0A2	10-17

*See table 6.2, p. 6-30

Symbol	*Mfr. Code	Description	Weinschel Part No.
	W/E	Piston Attenuator and Readout Assembly	D118-163
	W/E	Dial, Modified	B118-2
	W/E	Scale, Modified	B118-3
XTAL	F	Crystal, 30.000 Mc, .005% (3rd Overtone)	12-60

Table 6.2

MANUFACTURER'S CODE

A	Aerovox	S	General Electric	JJ	Raytheon
B	Allen Bradley	T	General Instrument	KK	Sarkes-Tarzian
C	Amphenol	U	General RF Fittings	LL	Sprague
D	Amp Inc.	V	Goodall	MM	Stancor
E	ARCO	W	Grayhill	NN	Switchcraft
F	Bliley	W/E	Weinschel	OO	Sylvania
G	Bryant	X	Gremar	PP	Texas Instruments
H	Burnell	Y	Honeywell	QQ	Westinghouse
I	Cannon	Z	International Prod.	RR	Stanwyck
J	Centralab	AA	International Rect.	SS	Belden
K	Cornell-Dubilier	BB	JFD	TT	
L	Cutler-Hammer	CC	Littlefuse	UU	
M	Dale	DD	Mallory	VV	
N	Elco	EE	Merit	WW	
O	Electra	FF	Motorola	XX	
P	Erie	GG	Ohmite	YY	
Q	Film Cap.	HH	Plastic Cap.	ZZ	Any tube brand meeting RETMA standards
R	FXR	II	Potter & Brumfield		

*See table 6.2

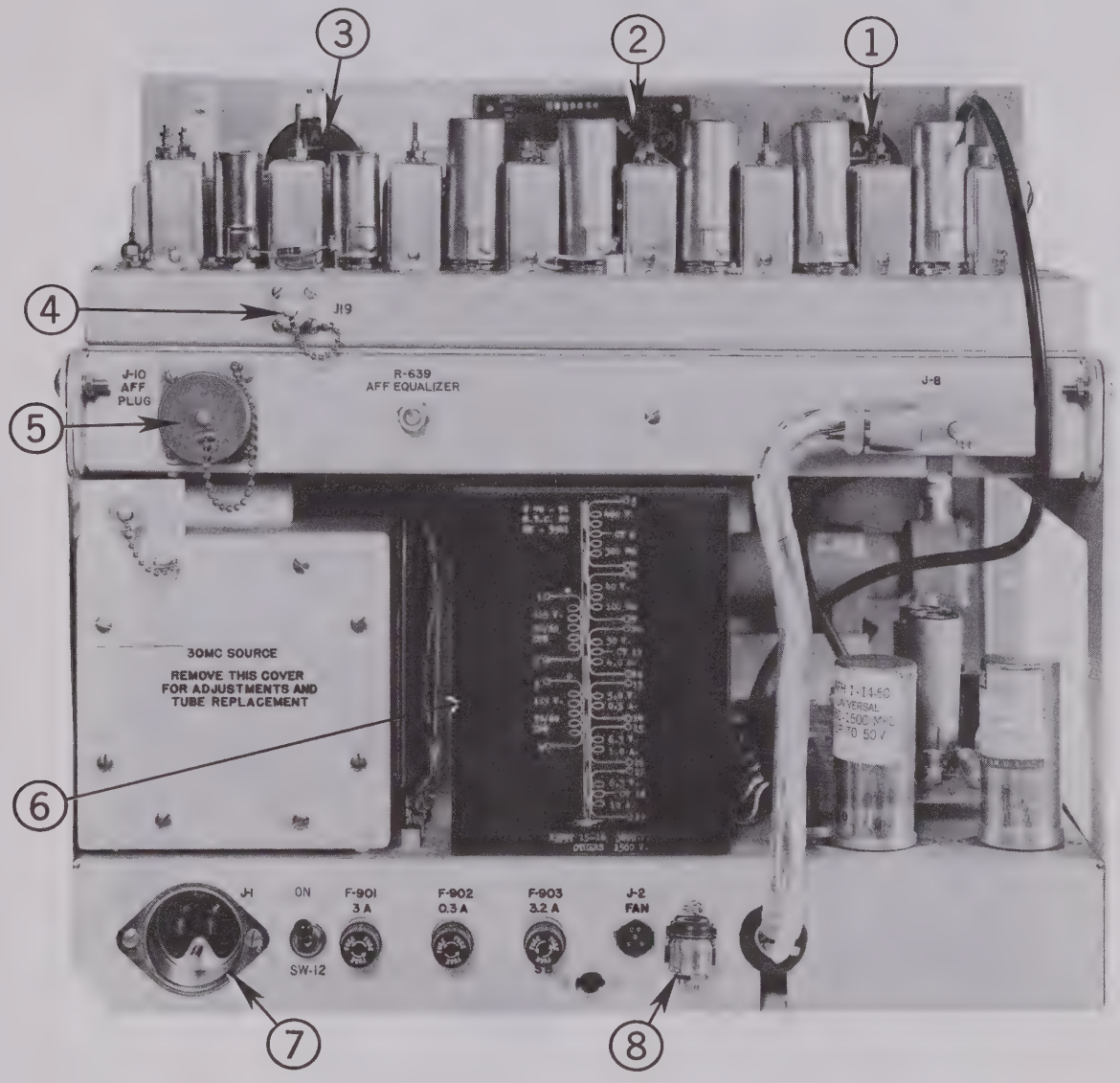


Figure 6.1 Rear View, Model VM-3, Cabinet Removed

1. M-2
2. M-1
3. M-3
4. J-19 Video Output (Square Law)
5. AFF Cable Connection
6. T-901
7. A/C Voltage Input
8. Dummy Connector for Interlock

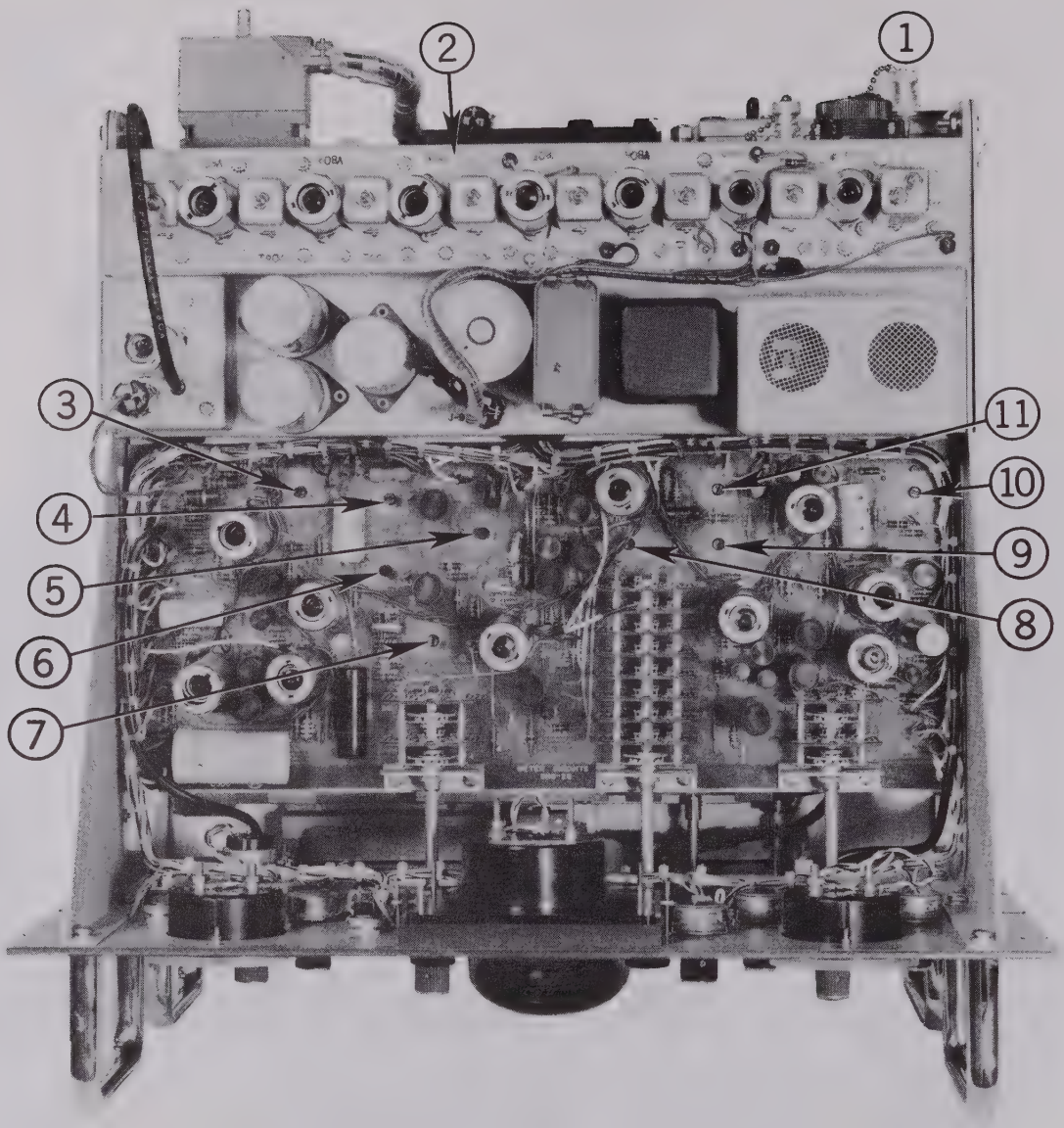


Figure 6.2 Top View, Model VM-3, Cabinet Removed

1. J-16, 30 Mc Output
2. I. F. Amplifier
3. R-406 AGC ADJ.
4. R-708
5. R-701
6. R-710
7. R-737
8. R-725
9. R-727
10. R-623
11. R-726

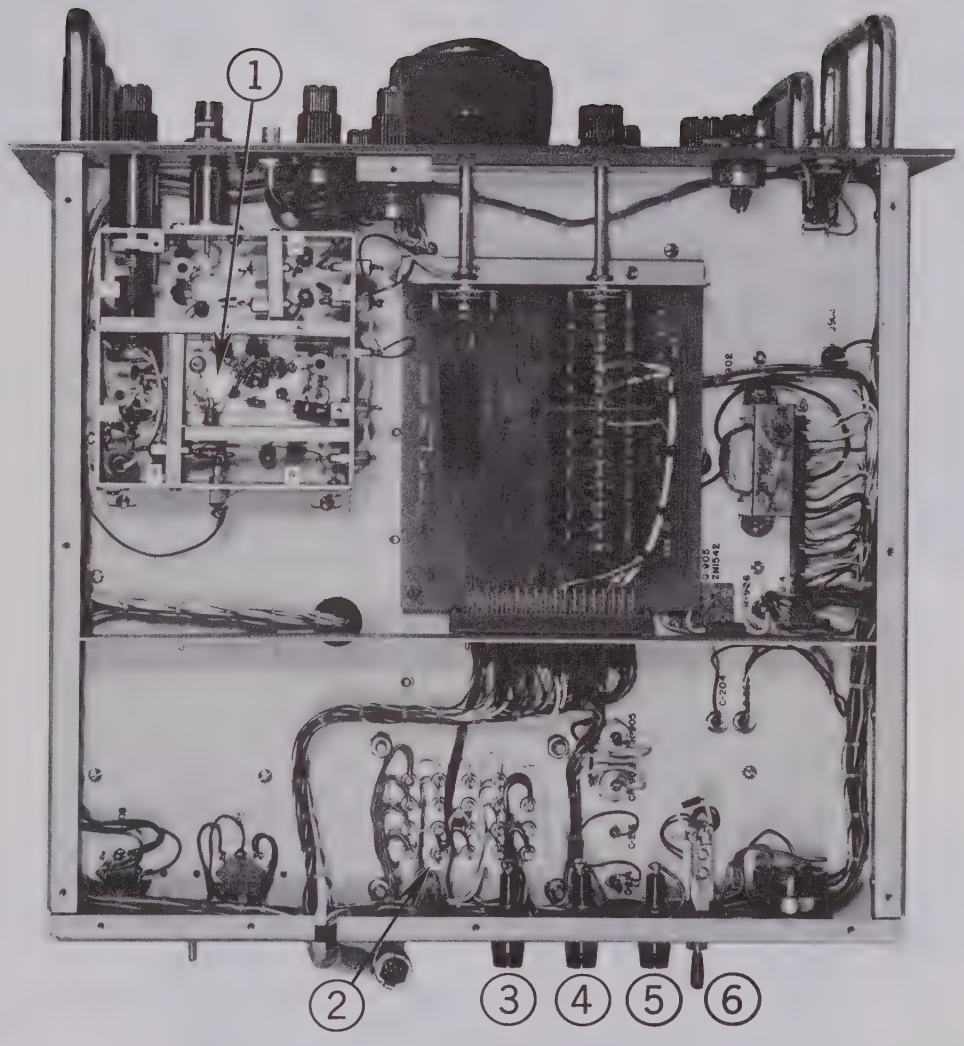


Figure 6.3 Bottom View, Model VM-3, Cabinet Removed

1. Noise Source
2. T-901
3. F-903
4. F-902
5. F-901
6. SW-12 ON-OFF 30 MC Switch

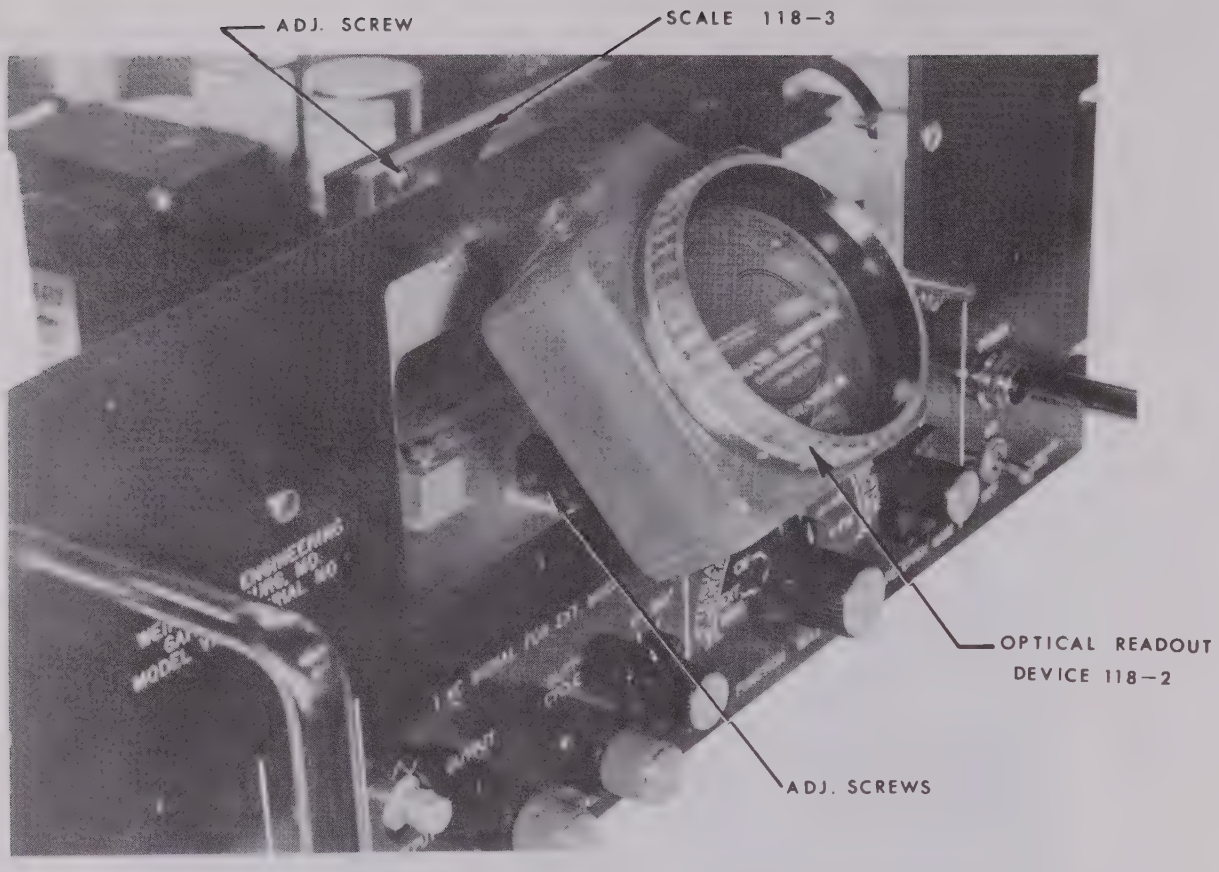
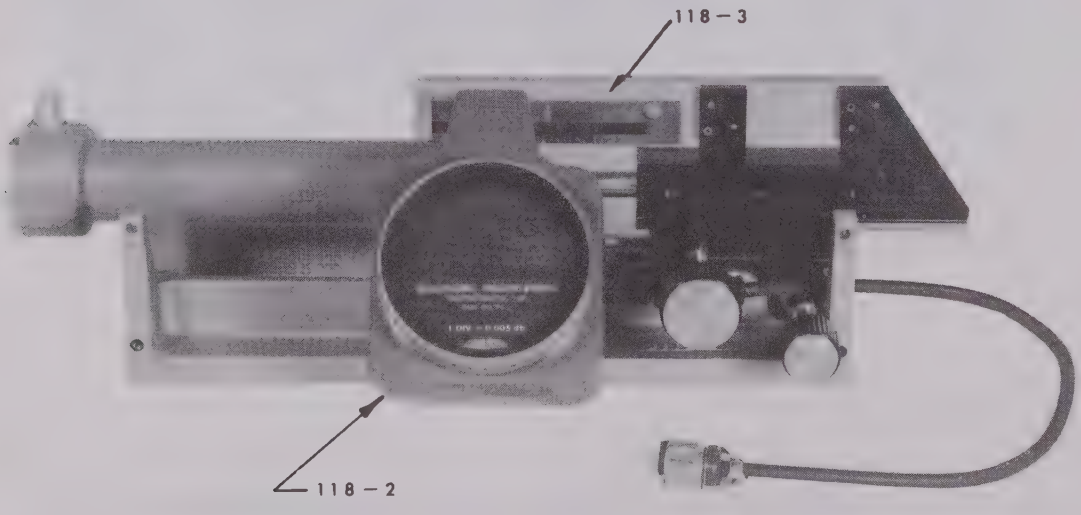


Figure 6.4 Close Up View of Readout Device, Face Plates Removed



PART NO. 118-163

Figure 6.5 Front View of 30 MC Attenuator and Readout Assembly, Removed from VM-3

SECTION VII

APPENDIX

MODIFICATIONS FOR AFF OPERATIONS

Simplified AFF Circuit

The VM-3 AFF circuitry is designed to operate in conjunction with the Weinschel Models MO-3, MO-4, and MO-5 Power Supplies. To use the VM-3 with other supplies requires modification of either the supply or the VM-3 itself. As may be seen in Figure 7.1, V-605 operates as a DC amplifier. It has a zero signal resistance of about 82K. Under these conditions the correct repeller voltage is applied to the klystron by the MO-3, MO-4, or MO-5 Power Supplies.

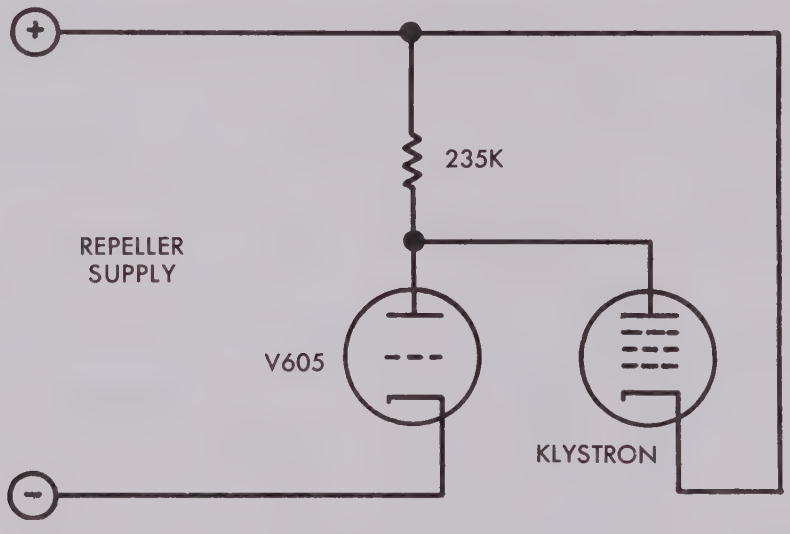


Figure 7.1. General AFF-Klystron Configuration

KLYSTRON POWER SUPPLY MODIFICATION

To modify a power supply other than the Weinschel Engineering Models MO-3, MO-4, or MO-5 for operation with the VM-3 AFF circuit, the following procedure is required:

(1) Measure the klystron repeller voltage (the voltage between repeller and cathode) at same frequency setting.

(2) Break the repeller lead at its first connection to the repeller supply or tracking potentiometers.

(3) Connect an 82K, 2W resistor in series with the repeller lead at this point.

(4) Connect a pair of 470K, 2W resistors in parallel (235K) between the repeller and cathode of the klystron.

(5) Remove any capacitance which might be connected directly between the repeller and cathode of the klystron.

(6) Adjust the repeller supply voltage and/or the tracking potentiometers to obtain the same repeller to cathode voltage measured in Step 1.

(7) Check frequency and power output over the full range of the klystron.

(8) Now replace the 82K, 2W resistor with the VM-3 AFF Circuit by connecting J10-A to the junction of the klystron repeller and the 235K combination, and J10-B to the original repeller lead as indicated in figure 7.2.

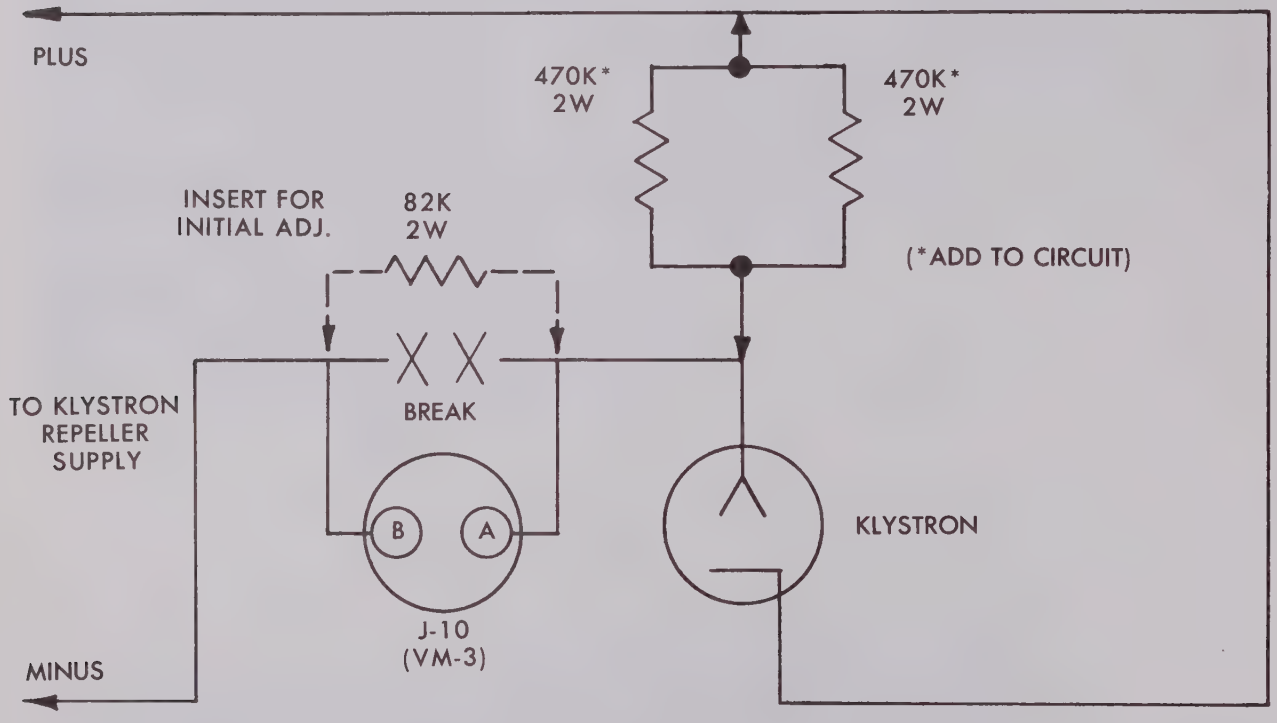


Figure 7.2. Klystron Power Supply Modification

VM-3 MODIFICATION FOR AFF OPERATION WITH KLYSTRON SIGNAL GENERATORS SUCH AS THE HP 8600 SERIES

To modify the VM-3, remove V-605 and jumper pin 1 to pin 2 at the V-605 tube socket. Refer to Figure 7.3. This now makes the AFF correction voltage directly available at J-10. This voltage may be applied to the two-terminal rear panel connector (External FM) on the HP 8600 Series Signal Generators, or to the direct-coupled FM input for other klystron signal generators. In the event that a direct coupled FM input is not available, it will be necessary to break the klystron repeller lead so the AFF correction voltage may be series connected. Refer to Figure 7.4.

MANUAL REVISION PAGE

AFF OPERATION WITH KLYSTRON SIGNAL GENERATORS (HP 8600 SERIES AND THE LIKE)

The VM-3 AFF output circuitry, as modified, now contains a two-position lever switch (SW13) on the rear apron of the top chassis. When the switch is in the DC AMPLIFIER position, the DC amplifier, V605, is connected as before. With SW13 in the DIRECT position, the AFF correction voltage bypasses V605 and is directly available at J10.

This voltage may be applied to the two-terminal rear panel connector (EXTERNAL FM) on the HP 8600 series signal generators, or to the direct-coupled FM input of other klystron signal generators. In the event a direct-coupled FM input is not available, the klystron repeller lead of the generator should be opened so that the AFF correction voltage from the VM-3 may be series-connected.

See figure 7.4.

NOTE

Please insert this page in the VM-3 Instruction Manual following p. 7-2.

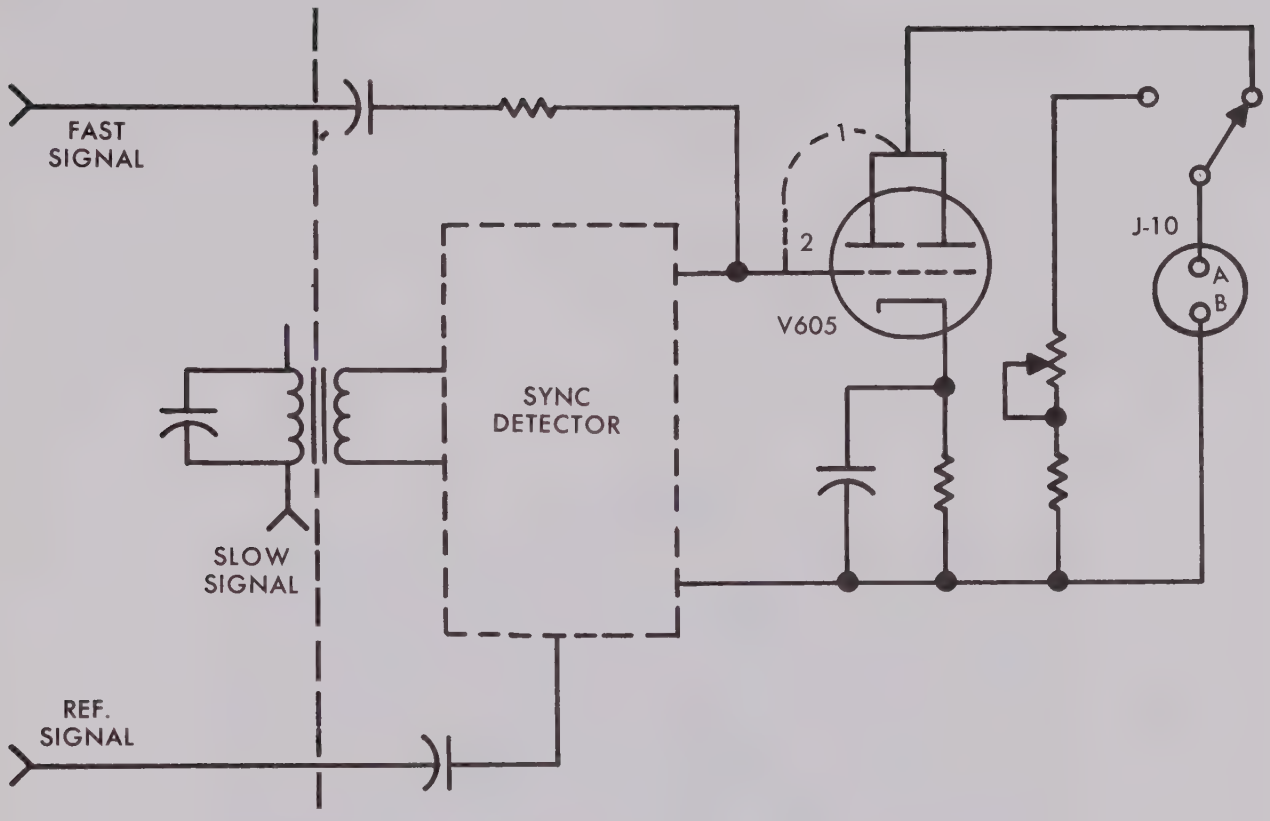


Figure 7.3. Simplified AFF Circuit Schematic

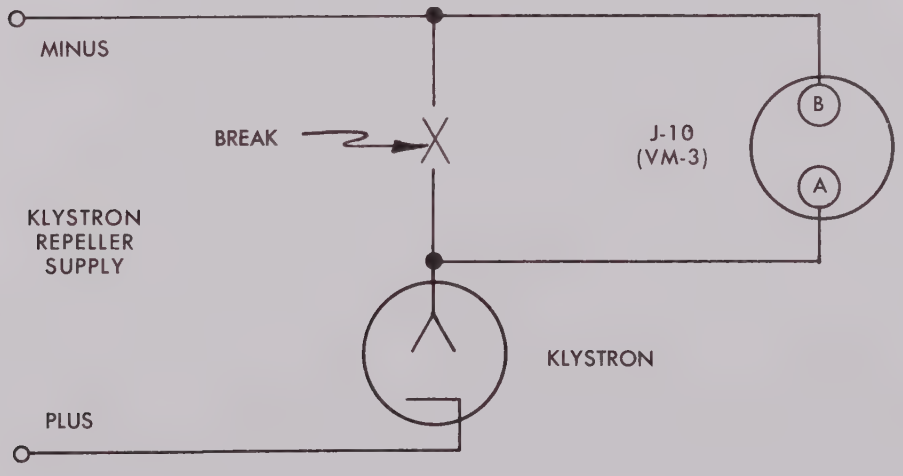


Figure 7.4. Klystron Repeller Lead Insertion Point

WARRANTY

WE WARRANT each instrument of our manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to making good at our factory any part or parts thereof except tubes, fuses or batteries. This warranty period is limited to one year after making delivery to the original purchaser, and to equipment which is returned to us with transportation charges prepaid and which, upon our examination, shall be disclosed to have been defective or to have failed in normal service.

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